SCIENCE ABSTRACTS.

Section A.—PHYSICS.

AUGUST 1915.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

AUGUST 1915.

GENERAL PHYSICS.

962. *Sealing Electric Conductors through Glass.* **F. F. S. Bryson.** (Nature, 95. pp. 370–372, June 3, 1915.)—The author recommends the method of G. B. Burnside [see Abs. 914B (1913)] which has enabled him to continue spectroscopic experiments with discharge tubes for hours. The Pt-wire is loosely inserted into the end of the tube, which is then heated by the blowpipe and drawn out a few mm., so that a short neck of glass adheres to the wire; when the glass has sufficiently cooled, the neck is dipped into oil, several times, each time a little deeper, until the joint is quite cold. Burnside recommended sperm oil; but machine oil, and also fat or wax, will answer. Sometimes the wire is first fitted with a glass sleeve. The method is applicable for sealing copper and iron into lead glasses as well as for fitting Pt electrodes into quartz or Jena glass. H. B.

963. *Harmonic Motion of a Rigid Body.* **G. Greenhill.** (Cambridge Phil. Soc., Proc. 18. pp. 135–136, June, 1915.)—Criticises and makes suggestions with reference to the carrying out of Searle's experiment on the harmonic motion of a rigid body [Abs. 888 (1915)]. It is suggested that a simple pendulum be used and adjusted to synchronism with the torsional oscillations. The measurement of the length of this equivalent simple pendulum can be made with considerable accuracy. Various corrections are dealt with. A. W.

964. *Optical Periodograph.* **A. E. Douglass.** (Astrophys. J. 41. pp. 173–186, April, 1915.)—Experience with a photographic application of the periodogram method of analysing statistics suspected of periodicity [see Abs. 264 (1915)] has induced the author to extend and improve the method. Examples of the working are given for rainfall and tree growth. The instrument permits, in a short time after plotting, the examination of all possible periods in a curve and their variations, so that the measuring and recording of the promising ones may be undertaken without delay, and it is hoped thereby to save many long computations. C. P. B.

965. *Practical Method for Evaluation of Integrals.* **R. Slaby.** (Zeits. Vereines Deutsch. Ing. 58. pp. 1348–1349, Aug. 20, 1914.)—A practical method is described for the evaluation of integrals of the form $\int f(x)\psi(x)dx$. The method consists essentially in displacing each point of the curve $y=f(x)$ parallel to the y-axis by an amount $\int\psi(x)dx$, and then determining the area between the new curve obtained and the curve $y=f(x)$; this gives the value of $\int f(x)\psi(x)dx$. Applications of the method to the evaluation of static moments and moments of inertia are given. A. W.

966. *Calibration of Testing-machines.* **P. Breuil.** (Rev. de Mét. 12. pp. 161–178, March, 1915.)—The direct method of calibration by the employment of weights is somewhat cumbersome and in many cases impracticable (as for horizontal machines). Calibration by the testing to failure of two portions of the same steel bar, one piece being broken on a standard machine and one on the machine to be calibrated, is liable to an error of at least 2 % owing to lack of homogeneity in the steel. The method depending on the compression or extension of a test-piece by forces well within its elastic limits involves very accurate measurement of the small deformations produced, and it is therefore necessary to employ some magnifying device, such as an arrangement of mirrors, for this purpose. The same principle has been used, but in a modified form, by the firm of Amsler Bros., of Schaffhouse, whose test-piece consists of a hollow cylinder filled with mercury and communicating with a small glass capillary tube, so that any change of volume in the cylinder is at once noted by a motion of the mercury meniscus in the capillary. A small cylinder containing a needle plunger which can be moved in and out by means of a graduated screw, provides a means of producing small volume-changes in the cylinder, and so of adjusting the position of the mercury meniscus. On the application of force, either tensile or compressive, to the ends of the cylinder, the volume undergoes a change, and hence the mercury in the capillary moves. It is brought back to its original position by moving the plunger, and the amount of this movement gives the required change of volume. Previous calibration enables the force applied to be deduced from this change of volume. It has been found, in fact, that the change of volume is very nearly proportional to the force applied, the actual relation found being $a=b\mathrm{P}^n$, where a is the extension due to a force P, b is a constant, and n has a value slightly different from unity. Direct comparison with a solid test-piece, in which the deformations were measured by a delicate mirror magnifying device, showed that the two methods were of equal sensitivity, while the advantage of robustness and convenience lay with the hollow-cylinder apparatus. J. W. T. W.

967. *Elasticity Constants of Simple and Compound Bars by their Pitches.* **O. Grögor.** (Phys. Zeitschr. 15. pp. 788–793, Sept. 15, 1914.)—Illustrates by five photographs an experimental method of obtaining the rigidity and Young's modulus by the longitudinal and torsional vibrations of bars, simple and compound. It was used for brass, iron, steel, and glass. E. H. B.

968. *Mechanical Anisotropy of Large-grained Metals and Alloys and the Ball Test.* **A. Portevin.** (Comptes Rendus, 160. pp. 844–846, March 15, 1915.)—Metals and alloys are built up of grains which are anisotropic; the mechanical properties of a single grain will, therefore, be functions of the direction in which the test is made. In the majority of cases the grains are

small and the differences are equalised in the aggregate, so that the mass behaves as if it were isotropic. In slowly-cooled cast materials the grain-size may become large enough to render anisotropy evident, more particularly by the ball test. The author has therefore prepared alloys in which the grain-size was purposely made large by very slow cooling from the molten state Impressions were made by a ball in single grains and measurements in two directions at right angles to each other revealed differences of as much as 29 % from the mean value. F. C. A. H. L.

969. *Combined Bending and Torsional Strength of Cast Iron.* **T. Matsumura and G. Hamabe.** (Kyōtō Coll. Eng., Mem. 1. 2. pp. 47–53, Feb., 1915.)—The results of recent work on the elastic failure of mild and harder steels do not agree closely with the principal stress theory of Rankine nor with the principal strain theory of St. Venant, but rather support the hypothesis enunciated by Mohr in 1900, which may be stated as follows:—The elastic failure of a ductile material or the breaking of a brittle material takes place when the shearing stress acting at a point along a certain plane, attains a limiting value which is a function of the normal stress at that point. The results carried out by the authors on a series of cast irons in a machine designed on the principle of the Coker testing-machine show that for cast iron St. Venant's theory applies in a most satisfactory manner. A remarkable point about the fractures is that as the ultimate torsional moment increases the section of fracture becomes more inclined to the plane normal to the axis of the test-piece. F. C. A. H. L.

970. *Comparative Study of Simple Shock Tests, Repeated Shock Tests, Rotary Bending Tests, and Alternating Bending Tests.* **Nusbaumer.** (Rev. de Mét. 11. pp. 1188–1190, Nov., 1914.)—A brief historical review of the subject of shock testing is given, and it is pointed out that the tests which have been devised do not always give concordant results. The author has therefore undertaken a systematic investigation of the results given by various methods of testing on metals which are as closely comparable as possible. Simple shock tests were made by Frémont's method, repeated shock tests by Stanton and Bairstow's method [Abs. 870 (1910)], rotary bending tests by the Wöhler method, and vibratory bending tests by Boudouard's method [Abs. 295 (1911)]. Tests were made on steels of varying carbon-content, on Ni steels, and Cr-Ni steels in the forged, annealed, and heat-treated conditions. The results show that up to 0·3 % C. the resistance to rotary bending, repeated shock and vibratory stresses is directly proportional to the carbon-content. Above this carbon-content the same relationship is maintained for rotary bending and vibratory stresses, but the resistance to repeated shocks now become inversely proportional to the carbon-content. Steels with a low Ni-content generally resist repeated shocks and vibrations better than simple steels of the same carbon-content. Steels with a high content of Ni offer no superiority over simple steels of medium carbon-content. Nickel-chrome steels resist repeated shocks and vibratory stresses better than Ni-steels, but in this series it is the low-carbon steels which present the max. resistance. Quenching followed by tempering raises the resistance to repeated shocks and vibrations of carbon steels and low-nickel steels, but tends to diminish the resistances of chrome-nickel and high-nickel steels. Simple quenching raises the resistance to repeated shocks of low-carbon and of low-nickel steels. However, it reduces the resistance of low-carbon nickel-chrome steels, and still more diminishes the resistances of hard steels and of high-nickel steels. Simple quenching diminishes the resistance to vibratory stresses of carbon steels and of low-nickel steels; on the other hand, the resistance of Cr-Ni steels is increased by this treatment. Other things being equal, the greater the resilience of a metal as revealed by the Frémont impact test the greater will be its resistance under the other varieties of shock tests. In all repeated-stress tests the fracture is caused by successive fissuration. F. C. A. H. L.

971. *Influence of Time on the Cohesive Properties of Colophonium-Wax Mixtures.* **F. Hauser.** (Deutsch. Phys. Gesell., Verh. 17. 6. pp. 95–103, March 30, 1915.)—The author finds that during a period of 70 days the cohesive properties of colophonium and of colophonium-wax mixtures, with from 2 to 6 % of wax, remain constant within the limit of experimental error. The brittleness of pure colophonium decreases in consequence of the gradual elimination of the strains produced in casting, whereas the brittleness of the mixtures increases in consequence of the crystallising out of the wax. Over and above this, immersion in water for several hours has an influence, as yet inexplicable, on the cohesive properties of the materials investigated. This influence alters with the age of the rods of material used. A. F.

972. *Einstein and Grossmann's Theory of Gravitation.* **A. D. Fokker.** (Phil. Mag. 29. pp. 77–96, Jan., 1915.)—Einstein considers of fundamental importance the fact that all bodies fall with the same acceleration. He assumes the conservation of energy as fundamental, and the validity of the principle of relativity in so far that its formulæ are to be assumed to be correct whenever the gravitation potentials are constants independent of the co-ordinates. Starting from these ideas a field of gravitation is formulated mathematically, not in terms of a single potential, but in terms of a set of ten potentials, components of a symmetrical tensor. Further, the important thing which is acted upon by gravitation and which produces the field, formerly the "mass" alone, is in the present theory a tensor of stresses, momenta, currents of energy, and energy. His basic "equivalence hypothesis" assumes the equivalence of a homogenous field of gravitation and a uniform acceleration of the system of co-ordinates. The author puts it as follows:—"We may put the equivalence hypothesis in another form. If we know the laws of motion in a field without gravitation, we know the differential equations connecting the time and the co-ordinates referred to a certain system of co-ordinates. We are not obliged to describe the motion with reference to this system. If we choose to do so, we may describe the motion with reference to another system which relatively to the first is uniformly accelerated. Of course we shall have then to introduce alterations in our equations. The equivalence hypothesis states that the alterations to be introduced are the same as those which we have to make when there is a homogeneous gravitation field affecting the motion. It extends this statement beyond the region of mechanics. It assumes that for all physical phenomena, when we give the laws referred to an accelerated system of co-ordinates, the differential equations will undergo the same variations from what they were in the resting systems, as they would suffer if we produced a gravitation field."

In this theory inertia becomes a merely relative quantity, the inertia of a particle being increased by the approach of other masses, and a sudden acceleration of neighbouring masses causing an acceleration of the particle. Such effects would, however, be too small for any reasonable expectation of making use of them to test the theory. The great achievement of the theory, according to the author of the paper, is the general covariancy of the equations.

The largest effect predicted by the theory occurs in the case of the bending of light-waves in a strong gravitational field. For example, a light-ray passing near the sun's surface should be deflected through an angle of 0·83″, so that the position of a star when the sun appears as nearly touching it should be shifted away from the sun's centre. Another consequence of the theory would be the influence of the gravitation potential on the rate of action of physical processes. For example, the vibrations in the atoms should be slower at the sun's surface than on the earth. G. W. DE T.

973. *Potential of Ellipsoidal Bodies and Figures of Equilibrium of Rotating Liquids.* **J. H. Jeans.** (Roy. Soc., Phil. Trans. 215. pp. 27–78, 1915.)—The author employs the term ellipsoidal body to denote any homogeneous body which can be obtained by continuous distortion of an ellipsoid. The main interest of the potential problem arises from its application to determining the possible figures of equilibrium of a rotating liquid mass. The latter theory is in an unsatisfactory state. Kelvin has shown that the Jacobian ellipsoid is stable at the point where it coalesces with the Maclaurin spheroid, and Poincaré has shown that it remains stable up to the point at which the Jacobian series coalesces with the Poincaré series of pear-shaped figures. After this point Poincaré's theory of exchange of stabilities at a point of bifurcation shows that the Jacobian series must lose its stability, but how it does so is in doubt. Darwin arrived at the conclusion that the Poincaré series is initially stable [Abs. 959 (1903)], while Liapounoff [Abs. 1841 (1906)] maintained it to be initially unstable. The author calls to mind Poincaré's warning [Collected Scientific Papers, 3. p. 392] that no absolute cosmogonic conclusions can be drawn from the stability or unstability of homogeneous bodies, the actual bodies not being homogeneous. A lengthy mathematical investigation, starting with the development of a method for writing down the potentials of certain homogeneous solids, in particular of ellipsoids and distorted ellipsoids, has led the author to the conclusion that underlying the whole question there is a complication, unsuspected equally by Poincaré, Darwin, and, as far as the author can read his writings, Liapounoff, which renders nugatory the work of all these investigators on the stability of the pear-shaped figure. It appears from the author's investigation, unless vitiated from some undiscovered error, that it is impossible to draw any inference as to the stability of the pear from computations carried only as far as the second order of small quantities. The materials for an answer to the question are to be found only through terms of higher order. He points out that the method here employed admits of indefinite extension, limited only by the labour of computation. In the parallel investigation on cylinders it was found that the stability could be examined as soon as the figure was determined to third-order terms, and he anticipates that the same will be the case in the present problem. It ought therefore to be possible to proceed to third-order terms, and determine the stability of the pear, and if the pear then proves to be stable, to proceed to higher orders and so examine the series of pear-shaped forms. In his investigation on cylinders the author found that an expansion as far as fifth-order terms gave a good approximation to the pear-shaped figure up to a stage where it was obviously just about to divide into two separate masses, and the present paper is published only in the expectation that he will be able to carry the investigation further.

G. W. DE T.

974. *Contributions to Hydrodynamics.* I. **C. W. Oseen.** (Ann. d. Physik, 46. 2. pp. 231–252, Jan. 28, 1915.)—The author has previously shown

that the theories of Green-Dirichlet and Helmholtz-Kirchhoff for the motion produced by the passage of a rigid body moving with constant velocity through a frictionless liquid are incorrect. His method was to transform the differential equations obtained by Stokes and Navier for the motion of a viscous fluid under the same circumstances into a system of integral equations, and instead of taking the limits for $\mu=0$ (*i.e.* for frictional disappearance) in the differential equations, to make the necessary substitutions in their integral equations. In one special case, at all events, a system of equations was obtained from which was deduced the fact that although the fluid motion be otherwise unaccompanied by eddies, yet behind the moving body eddy development ensues. The author now employs this method to investigate not only stationary movements but also the general case. A detailed mathematical exposition is given from which the following conclusions are drawn :—(1) The limiting substitution for $\mu=0$ must not be made in the differential equations, but in the integral. (2) The first step consists in solving the differential equations with known limits and with a very small positive μ, omitting for simplification the quadratic terms. In many cases the problem now resolves itself into the determination of a potential function ϕ. (3) If S be the surface of a rigid body which moves with positive velocity U(t) parallel to the x-axis, and if n be the outer drawn normal, then the conditions for the determination of ϕ are : $d\phi/dn = \mathrm{U}(t)\cos(nx)$, when $\cos(nx) \geqq 0$; $\mathrm{div}(\mathrm{grad}\ \phi)_{\mathrm{S}=0} = \partial/\partial x\mathrm{U}(t)_{\mathrm{S}=0}$, when $\cos(nx) < 0$. (4) In some cases the function ϕ may be determined in a simple way. (5) A frictionless liquid slips at the front of a rigid body, but adheres at the rear. H. H. Ho.

975. *Moment of Inertia.* **D. J. McAdam.** (Science, 41. p. 805, May 28, 1915.)—The true definition of moment of inertia must define it as the moment of forces just as truly as any other moment of forces ; and it must state the unit of force or of acceleration in which the forces are expressed. The moment of inertia of (*a*) a particle with reference to a point is the moment of the force which, acting upon the particle constantly at right angles to the line joining the particle to the point and acting constantly in the same plane, will produce unit acceleration. The moment of inertia of (*b*) a beam at a section is the sum of the moments of the forces which are acting on the various elements of the section when the outer elements are stressed, so that there is unit stress at unit distance from the neutral axis. In (*a*) the unit force is one producing unit acceleration ; in (*b*) the unit force is unit intensity at unit distance from the neutral axis ; both are forces, however, expressed in terms of a unit force. In the expression for the moment of inertia of a mass about an axis parallel to the axis through its centre of gravity, the term to be added to the moment of inertia of the body about the axis through its centre of gravity is the moment of the force which will have to be applied to the mass at its centre of gravity to cause it to have radian acceleration. This we find to be $\mathrm{F}r = mr^2$. A. D.

976. *Resistance of Small Plates in a Stream of Fluid.* **Rayleigh.** (Phil. Mag. 29. pp. 179–181, July, 1915.)—In a recent paper on Æolian Tones [see Abs. 718 (1915)] the author had occasion to determine the velocity of wind from its action upon a narrow strip of mirror, the incidence being normal. But there was some doubt as to the coefficient to be employed in deducing the velocity from the density of the air and the force per unit area. Observations both by Eiffel and by Stanton had indicated that the resultant pressure (force per unit area) is less on small plane areas than on larger ones ; and although the author used provisionally a diminished value of C in the equation $P = C\rho V^2$ in view of the narrowness of the strip, it was not without hesitation; in fact, experiments had already been commenced which appeared to show that no variation in C was to be detected. Subsequently the matter was carried a little further, and the method is here described.

According to the principle of similitude a departure from the simple law would be most apparent when the kinematic viscosity is large and the stream velocity small. Thus, if the delicacy can be made adequate, the use of *air* resistance and such low speeds as can be reached by walking through a still atmosphere should be favourable. The principle of the method consists in balancing the two areas to be compared by mounting them upon a vertical axis, situated in their common plane, and capable of turning with the minimum of friction. If the areas are equal, their centres must be at the same distance (on opposite sides) from the axis. When the apparatus is carried forward through the air, equality of mean pressures is witnessed by the plane of the obstacles assuming a position of perpendicularity to the line of motion. If in this position the mean pressure on one side is somewhat deficient, the plane on that side advances against the relative stream until a stable balance is attained in an oblique position, in virtue of the displacement (forwards) of the centres of pressure from the centres of figure.

Several arrangements were tested, viz., rectangular strips of equal area, one three times the breadth of the other, circular discs of area 2 : 1, one disc and two others of total area equal to the first. No deviation from the simple law was detected. E. H. B.

977. *Relation between the Most Probable and the Mean State in Statistical Mechanics.* **K. F. Herzfeld.** (Phys. Zeitschr. 15. pp. 785–788, Sept. 15, 1914.)—Proves that, with certain limitations, in Boltzmann's relation $S = k \log W$, instead of taking W as the number of the complexions in the most probable state, that for all possible states with given conditions may be taken. [See Abs. 505 (1913).] E. H. B.

978. *Brownian Movement as Function of Viscosity. Theory of Systematic Errors.* **K. Seelis.** (Zeitschr. Phys. Chem. 86. pp. 682–789, 1914.)—Critically reviewing the work of Einstein, Seddig, Perrin, the author measures the viscosity of mixtures of glycerol (up to 75 %) and water in a capillary-bulb apparatus after Thorpe and Rodger, the flow taking place at about 25° C. and under a water-head of from 4 to 8·4 cm. Poiseuille's formula for the flow can be applied with Hagenbach's correction. The displacement of cinnabar particles in these mixtures is then studied. The calculation of the results suggests a systematic error; the author hence intercalates into his article a long extract from *The Theory of a Suspicion of Systematic Errors*, published by F. Richarz and E. Neumann in the Marburg University Programme of 1909. The glycerol-water mixtures generally agree with Einstein's formula except for the range 20 to 50 % of glycerol, for which the observed displacement is only half the theoretical. The reasons for the divergence seem to be that complex molecules are formed, and that the particles, being in reality sharp-edged instead of globular grains, do not obey Stokes' law. A modification of this law leads to a satisfactory agreement with Einstein; the Avogadro constant would be $N = 7{\cdot}20 \times 10^{23}$, which is in excellent agreement with Perrin. The influences of temperature and of internal friction are further to be examined in a medium of very high viscosity and with particles of different origins. H. B.

979. *Chaotic Movement.* **K. Przibram.** (Phys. Zeitschr. 15. pp. 766–768, Aug. 15, 1915.)—By observing Brownian movements in pairs and recording the greater displacement of the two in each pair for *n* pairs and then taking the mean of these maxima and dividing by the root-mean-square of them a value is obtained which is a distinct and simple function of *n*. Plotted on a logarithmic base the graph is a straight line inclined to the axis of abscissæ.

Proceeding in the same way for living infusoria the graph is the same for moderate and large values of *n*, but the ordinates are greater for small values of *n*, the graph being here a curve, concave up. E. H. B.

980. *Gyroscopic Theory of Atoms and Molecules.* **A. C. Crehore.** (Phil. Mag. 29. pp. 310–332, Feb., 1915.)—In any atomic theory which makes the number of electrons in an atom proportional to its atomic mass the number of electrons per gm. will be approximately a universal constant, which will become the gm.-mol. constant 6×10^{-23} if the ratio be one of equality. Since, in neutral atoms, a positive electron of fixed volumes accompanies each electron, the volume of positive electricity per gm., being 6×10^{-23} times the volume of the positive electron, found in a previous paper [Abs. 1779 (1913)] to have the dimensions $2{\cdot}7 \times 10^{-36}$ cm.^{3}, corresponding to a sphere of radius $0{\cdot}86 \times 10^{-12}$. Thus the volume of atoms in 1 gm. will be $1{\cdot}62 \times 10^{-12}$—a significant result in view of Lodge's conclusion that the minimum value of ether density is of order 10^{12}. The atomic mass is accounted for by the larger volume of positive electricity, the ratio of the volumes $+ ve/- ve = 1900 =$ mass of H-atom/mass of electron. Beta particles may come from any electron in the atom, the orbits being of order 10^{-12} cm., while the central-nucleus theory precludes their emission from the outer rings. The theory shows a major limiting atomic weight when the outer ring equals the positive electricity in diameter. This occurs somewhere near U, and self-radioactivity is attributed to the instability of this outer ring near this limit, which would account for confinement of self-radioactive elements to the latter end of the periodic system. Röntgen radiation is explained as due to rapid nutations, natural and forced, due to disturbance of steady circular orbits. In the single electron or H-atom the natural nutation frequency is twice the frequency of orbital revolution, the orbital frequency being determined from Planck's constant together with the size of the H-atom to be $2{\cdot}385 \times 10^{19}$, and the characteristic Röntgen frequency for H should, therefore, be double this. For more than one electron the natural frequencies have so far been determined from the equations only by aid of the assumption that the frequencies are proportional to the number of electrons in a ring. This, with the further assumption that the grouping of electrons in rings corresponds to the periodic table, is shown to account for the $K\alpha$ and $L\alpha$ (Moseley) Röntgen-ray spectra. The comparatively low frequencies of light are attributed to precessional frequencies, and the proportionality of these to the impressed force accounts also for the still lower heat frequencies. A calculation for the single-electron atom shows agreement with Balmer's law. G. W. DE T.

981. *Constancy of Size of Mercury Spherules under Intense Radiation.* **F. Ehrenhaft.** (Phys. Zeitschr. 15. pp. 955–956, Dec. 15, 1914.)—Shows by microphotographs that the mercury droplets had not appreciably changed after exposure to half an hour's radiation. The author accordingly maintains his position against the criticisms of A. Schidlof and A. Karpowicz [see Abs. 1569 (1914)]. E. H. B.

982. *Absorption of Ultra-violet and Infra-red Radiations by Arable Soil.* **J. F. Tristan** and **G. Michaud.** (Archives des Sciences, 39. pp. 270–273, March, 1915.)—Photographs were taken in ultra-violet light through a quartz lens, silvered after Liebig, which is transparent to light of from 3100 to 3300 Å. units. For the photographs in the infra-red Wood's filters are used, made by Wratten and Wainwright; the preparation of these plates is described. The method for determining the absorption of the light by the soil is not explained at all. Eight pairs of photographs are reproduced showing the darkening of the plates by ultra-violet and by infra-red light, in each case by four soils (calcareous, sandy, clay, humus), in the dry or humid state. The dry soil absorbed much less infra-red light than the humid soil; this effect of moisture, which was most marked in the case of clay soil, was much less noticeable in the case of ultra-violet light. H. B.

983. *Isostasy and Compression of the Earth.* **W de Sitter.** (K. Akad. Amsterdam, Proc. 17. pp. 1295–1308, June 3, 1915.)—A long analysis is given of the application of isostatic data to the determination of the earth's moment of inertia, and a review of the relative accuracy of various measurements of the earth's compression, the best value of which is thought to be that determined from the constant of precession, giving $\epsilon^{-1} = 295{\cdot}96$. C. P. B.

984. *Cooling of the Terrestrial Crust considered from Fourier's Standpoint.* **J. Boussinesq.** (Comptes Rendus, 160. pp. 695–700, May 31, 1915.)—This paper is an extension of Fourier's work on terrestrial cooling relative to the central temperature and based on the following hypotheses: (1) That the crust is comprised between two concentric spheres, but owing to the relatively small thickness as compared with the earth's radius it may be treated as a horizontal plateau: (2) That the crust rests upon a fused sphere from which it had been solidified at the origin of time, and whose initial temperature can be regarded as that actually existing beneath the crust. The author discusses the problem mathematically, taking into account the external temperature at the surface with its periodic variations due to season and climate, and also considering chemical activity within the crust. H. H. Ho.

985. *Ordinary and Internal Seiches in Lake Tasawa.* **K. Honda.** (Tôhoku Univ., Sci. Reports, 4. pp. 33–42, 1915.)—As in previous investigations, the author constructed a model of this the deepest Japanese lake before making the actual observations, and found experimentally four periods for the fundamental and higher modes of oscillations. Generally speaking, the seiches are most conspicuous in deep lakes, and seldom observable in shallow, but here only faint undulations were detected using Honda's limnimeters for this purpose. The following causes are given for these inconspicuous seiches in such a deep lake: (1) The form of the lake being nearly circular there is no direction of easy oscillation; (2) surrounded on all sides by steep mountains the lake is generally very calm; (3) the depth being so great, a strong exciting cause is required to make the whole water oscillate. For the observation of the internal seiches, a Miller pattern deep-sea thermometer, which indicates the max. and minimum temperatures, was used. An adequate description of the operations is given and the following results were obtained:—Near the surface the fall of temperature is gradual, but at a depth from 10 to 16 m. is very rapid; afterwards it becomes again very slow, tending asymptotically to the temperature of the max. density of water, 4° C. The usual explanation for the existence of this apparent discontinuous layer is that near the surface the temperature is equalised by

the disturbing effect of currents and the waves in the lake. The depth to which the disturbance reaches depends upon its duration, increasing with the period of of disturbances. Down to this depth the fall of temperature is very gradual, but the conduction of heat being very small, the fall of temperature in a depth deeper than that where the disturbance nearly vanishes, follows a logarithmic law with respect to the depth. Hence the fall is at first very gradual, then very rapid, and afterwards becomes more and more slow, so that there is an apparent layer of discontinuity. Similar results are given for the lakes of Inawasiro and Towada. Tables of observations are given, and from the curves (temperature-time for constant depths, and depth-time for constant temperatures) two periods are deduced for the approximate values of periods of internal seiches. A short mathematical discussion concludes the paper from which it follows, that the two long periods recorded on the limnimeters are due to the internal seiches of the lake. Hitherto in the observations of the ordinary seiches, where the periods are large compared with the natural oscillations of the lakes, these are usually attributed to the effect of wind blowing with some periodicity of slow alternations. From the present investigation, however, the long periods are well explained by the internal seiches of the lakes. H. H. Ho.

986. *Accurate Collimation of Non-reversible Meridian Telescopes.* **M. Hamy.** (Comptes Rendus, 160. pp. 87–89, Jan. 18, 1915.)—Deals with the problem of accurate collimation in the less simple case presented by meridian instruments which cannot be reversed. L. H. W.

987. *Solar Halo.* **H. C. Richards.** (Science, 41. pp. 904–905, June 18, 1915.)—An interesting solar halo was observed on the morning of May 20 in the vicinity of Philadelphia (U.S.A.); the two prismatic circles seen round the sun were measured with a sextant, and found to have radii of 22° 10′, and 46° 45′, and were concentric with the sun. The parhelic circle was whitish, and had a radius of 20° 5′, corresponding to the solar altitude of about 70°. At the intersections of the circles there were slight increases of intensity, but no conspicuous parhelia. Two fainter arcs were seen intersecting the parhelic circle at the point opposite the sun; these if prolonged would have been approximately tangential to the 22° circle. The phenomenon was first noticed at 11 a.m. and faded away soon after noon. C. P. B.

988. *On the Solar Constant.* **F. W. Very.** (Am. J. Sci. 39. pp. 201–208, Feb., 1915.)—The author deals with Bigelow's determinations [see Abs. 1808 (1914)]. He considers that the bolographic argument for a value of the solar constant is sound, but that the primary pyheliometric reduction employed by Bigelow involves the assumption of a constant diurnal coefficient of transmission, which assumption is, in his view, erroneous. L. H. W.

989. *Rotation of Solar Corona.* **J. Bosler.** (Comptes Rendus, 160. pp. 434–437, April 6, 1915.)—During the eclipse of the sun on 1914 Aug. 21 photographs of the spectrum of the corona were obtained with a 3-prism spectrograph giving a dispersion of 1 mm. = 32 Å. The eclipse was notable in that the chief corona line in the green region at λ5303 was extremely faint, and, in consequence, determinations of the rotation have been confined to measurements of the new line discovered in the red at λ6374·5. Wave-length determinations were made from comparison spectra of the ordinary sunlight 10 minutes after totality. Taking into

account that the slit was inclined 18° to the solar equator, the resultant velocity of rotation of the corona gives an equatorial velocity of 8·9 km. per sec. This result is in good agreement with that obtained by Campbell in 1898. **H. Deslandres.** (Ibid. pp. 437–440, April 6, 1915.)—The importance of finding any definite value for the rotation of the solar corona is discussed from the point of view of its bearing on the theory of the constitution of the corona. Widely different values of the strength of the solar magnetic field have been obtained in different regions—a feeble value of 10^{-7} gauss by Deslandres, for the region of the high prominences, and a strong value of 50 gauss by Hale, for the lower layers of the solar atmosphere. If the coronal radiation is of the nature of electrified particles being projected outwards, it would be reasonable to expect some influence on their velocity owing to their passage through the electric field, and this would modify to that extent the measures of the rotation velocity by line-of-sight measurements at the limb. It is suggested that in future it would be better to arrange for an artificial comparison spectrum instead of using sunlight. [See Abs. 1437, 1438 (1911) ; 367 (1913).] C. P. B.

990. *Spectrum of Inner Corona.* **R. Furuhjelm.** (Ofversigt af Finska Vetenskaps-Societetens Förhandlingar, 57. No. 5. Nature, 95. pp. 353–354, May 27, 1915. Abstract.)—Photographs of the total solar eclipse of 1914 Aug. 21 were secured by the expedition from the observatory of Helsingfors, observing at Kumlinge, Aland Isles. A solar image of 36·4 mm. diam. was obtained, serving a 3-prism spectrograph giving a spectrum 33·7 mm. long from λ450 to λ590. Wave-lengths were determined as λ5303·38 for the green ray, and λ4566·81 for the green-blue ray. C. P. B.

991. *Variation of Telluric Lines with Solar Altitude.* **A. Perot.** (Comptes Rendus, 160. pp. 549–551, April 26, 1915.)—Observations having for their object the detection of wave-length variations of the spectrum lines produced by the absorption of the terrestrial atmosphere, have been made on the oxygen group of lines at B. If these gases are in motion sufficient to produce Doppler-Fizeau effects, it would be expected that variations would be detected depending on the altitude of the sun at the time of observation. The work was carried out with an interferential spectroscope at the Meudon Observatory, the results given showing that the wave-lengths increase from early morning to midday, then decrease again until evening. The velocity found is about 3/cm. per sec. away from the earth's surface, and it is thus evident that the employment of these telluric lines must be considered from this point of view. [See Abs. 854, 855, 1479 (1913).] C. P. B.

992. *Motions of Lunar Perigee and Node.* **W. de Sitter.** (K. Akad. Amsterdam, Proc. 17. pp. 1309–1321, June 8, 1915.)—The determinations of the sidereal motion of the lunar perigee fall into two classes, those in each class agreeing well with each other, but the mean of each class being somewhat different, more than can be explained by the mean errors. The results are used in an analysis of the probable distribution of mass in the moon. C. P. B.

993. *Mean Radius of Earth and Moon's Parallax.* **W. de Sitter.** (K. Akad. Amsterdam, Proc. 17. pp. 1291–1295, June 8, 1915.)—It has been already pointed out by Newcomb that the mean radius of the earth is more

appropriate as a standard of reference than the equatorial radius at present in general use. The most authentic of the published values are examined, and a mean determined. Depending on this, values are also given for the intensity of gravity and the moon's parallax. C. P. B.

994. *Physical Details on Saturn.* **P. Lowell.** (Astron. Nachr. No. 4800, March 11, 1915. Nature, 95. p. 358, May 27, 1915. Abstract.)—Measurements of the crepe ring of Saturn show a persistent excess on the east side over the west. Photographs taken on March 12 confirm visual observations in revealing that Cassini's division is visible in part above the contour of the ball by about four-tenths of its true width; from this a preliminary reduction gives the oblateness of Saturn to be about one-ninth. C. P. B.

995. *Calculation of the Force due to Gravity at the Surface of a Homogeneous Planet.* **U. Crudeli.** (Accad. Lincei, Atti, 23. pp. 499–503, Dec. 18, 1914.)—Mathematical.

996. *Capture Theory of Satellites.* **A. C. D. Crommelin.** (Observatory, No. 487. pp. 213–220, May, 1915. Reprint from "Scientia.")—The paper contains various notes in review of the "Capture Theory" proposed by T. J. J. See in his work on the evolution of the stellar system. Attention is called to the part played by an assumed resisting medium in the early days of the solar system; in particular it is suggested that the prevalence of the circular form in the planetary orbits is due to this cause. See asserts that all the satellites were formerly independent planets of the solar system, each having been formed by a separate aggregation of cosmical dust, and having attained to a finished state before it underwent capture. Crommelin does not accept these views, and instances the case of the thousands of comets which must have approached the sun within the historical period, but there is no case on record of any comet coming as near to the earth as the distance of the moon. A strong case against the capture theory may be drawn from the notable symmetry prevailing in the sizes of the satellite family of the giant planets. It is also extremely difficult to accept the capture theory for the origin of the rings of Saturn. Further evidence is available from the study of spectroscopic binaries, in which it is found that with advancing type the component stars do not necessarily approach each other. The facts seem to indicate that the components of binary stars begin their career in close proximity, with nearly circular orbits, and through the influence of tidal friction the distance between them increases, and the orbits become eccentric. The class of satellites which most closely supports the capture theory includes the outer small satellites of Jupiter. C. P. B.

997. *Ninth Satellite of Jupiter.* **S. B. Nicholson.** (Lick Observatory, Bull. 8. [No. 271] pp. 147–149, 1915.)—A short account of the discovery of this ninth satellite of Jupiter has already been given [see Abs. 416 (1915)]. A more rigorous reduction of the observations has resulted in the determination of a slightly changed position for one day, and a new reduction is given, with a set of elements which are thought to be sufficiently accurate to locate the satellite at the next opposition, for which an ephemeris will be issued. C. P. B.

998. *Baxendell's Observations of Variable Stars.* **H. H. Turner** and **M. A. Blagg.** (Roy. Astron. Soc., M.N. 75. pp. 398–425, March, 1915.)—A very detailed discussion is given of the observations made by Baxendell

of the variables S Geminorum, R Herculis, and S Herculis during the period 1857–1886, with tables giving material for construction of their light-curves. C. P. B.

999. *Measurement of Distances of Stars.* **F. W. Dyson.** (Nature, 95. pp. 383–387, June 3, 1915. Abstract of the "Halley Lecture," delivered at Oxford, May 20, 1915.)—A review is presented of the gradual evolution of methods of determining stellar distances, starting with the ideas of Copernicus in 1543, showing that the fact of most of the stars apparently keeping their relative positions unchanged for long periods was interpreted correctly as indicating their great remoteness compared with the members of the solar system. Subsequent observations by Hooke, Flamstead, Picard, and Cassini were unsuccessful, but in 1718 Halley succeeded in proving, indirectly, that the three bright stars Aldebaran, Sirius, and Arcturus were at sensible distances, because he found their positions different to those assigned by Ptolemy in the Almagest. The next important step was again indirect, but no less important, as it was the detection of stellar aberration by Bradley, using the zenith sector. This and another factor, the nutation, were of such dimensions as to mask any measures of parallax which might have been obtained up to that time. In 1781 Herschel drew attention to the difficulties of the problem, and proposed the differential measurement of bright and faint stars with a powerful telescope and micrometer. Piazzi, Brinkley, Pond, Bessel, and Struve continued the work, and some details of circumpolar stars were made by Struve at Dorpat between 1814 and 1821. Later Henderson worked on α Centauri in 1832, finding a parallax of about 1·0″. In 1838 there were available the first reliable parallaxes for α Centauri, 61 Cygni, and α Lyræ; other results were contributed by Peters (Pulkowa) in 1843, Auwers and Krueger in the 'sixties. Much more rapid progress occurred in the 'eighties, chiefly by Gill and Elkin, whose memoir was published in 1884. Observations with the transit instrument were made by Kapteyn at Leyden, but many precautions are necessary to determine the requisite corrections.

The application of photography to the problem was commenced by Pritchard at Oxford between 1887 and 1889. Schlesinger, at Allegheny, Russell and Hinks at Cambridge, Slocum and Mitchell at Yerkes, and the Greenwich observers have continued the investigation by the photographic method with extremely satisfactory results, the parallaxes of about 200 stars being now known with fair precision. It is now considered that for the distance of a star to be determined with any certainty it must not be greater than 10^7 times the sun's distance; this would correspond to a parallax of 0·02″.

The importance of determinations of stellar distances is emphasised, as we have already ample data concerning the positions, velocities, luminosities, and masses of many stars, which only need fixing in space to enable us to co-ordinate their physical conditions. C. P. B.

1000. *Scintillation.* **G. Bigourdan.** (Comptes Rendus, 160. pp. 536–541, April 26, and pp. 579–584, May 3, 1915.)—A *résumé* is given of the chief publications available regarding the phenomena usually grouped under the general name of scintillation. As part of the effect is possibly due to variations of atmospheric dispersion, it has been noticed that the degree of scintillation is dependent somewhat on the colours of the stars. In the second article the behaviour of the telescopic images of stars and other celestial objects is considered in relation to various atmospheric phenomena, such as during the prevalence of auroræ, magnetic storms, barometric variations, proximity to clouds, proximity to large expanses of water or the sea. C. P. B.

1001. *Stars with Peculiar Spectra.* **[Miss] Cannon.** (Harvard Annals, 76. No. 3. Observatory, No. 488. p. 262, June, 1915. Abstract.)—Discussion of 750 celestial objects known to have bright lines in their spectra results in their being divided into six groups. Four of these are specially treated in the present volume, including nebulæ, Wolf-Rayet stars, novæ, and stars of P Cygni type. C. P. B.

1002. *Magnitudes of Stars near North Pole.* **F. H. Seares.** (Astrophys. J. 41. pp. 206–236, April, 1915. Mt. Wilson Solar Observatory, Contrib. No. 97.)—This investigation was commenced in 1910, and certain preliminary results were published in 1913 [Abs. 946 (1913)]. Later the photographic scale was extended to the brighter stars and the results were discussed in relation to those given by other investigators [Abs. 198 (1914)]. The scale was then extended to the fainter stars, and a scheme finally adopted for the stars in the interval from 10th to 20th magnitude. The catalogue includes 645 objects altogether, but for publication only those (329) are included for which both photographic and photovisual magnitudes have been determined. C. P. B.

1003. *Parallaxes of Four Visual Binaries.* **F. Slocum.** (Astrophys. J. 41. pp. 237–246, April, 1915.)—From a series of photographs taken with the 40-in. refractor at the Yerkes Observatory determinations of parallax have been made for the four visual binary systems: 42 α Coma Berenices ($\pi = +0{\cdot}062''$); 2 η Coronæ Borealis ($\pi = +0{\cdot}076''$); 70 Ophiuchi ($\pi = +0{\cdot}216''$); 85 Pegasi ($\pi = +0{\cdot}088''$). C. P. B.

1004. *Stars with Large Proper Motion.* **A. van Maanen.** (Astrophys. J. 41. pp. 187–205, April, 1915. Mt. Wilson Solar Observatory, Contrib. No. 96.)—A list is given of 583 stars whose proper motion exceeds $0{\cdot}50''$ annually, which includes all those known up to 1914, with details of reference catalogue numbers, magnitudes, spectrum type, position co-ordinates, amount and direction of proper motion. C. P. B.

1005. *Radial Velocities of Class Md Stars.* **P. W. Merrill.** (Astrophys. J. 41. pp. 247–249, April, 1915.)—Radial velocities are given for 24 long-period variable stars of spectral class Md, determined from photographs obtained with the one-prism spectrograph attached to the 37½-in. reflector of the Detroit Observatory. The velocities depend in most cases upon measurements of the bright hydrogen lines H_γ or H_δ. It is noteworthy that in no instance is the velocity found to be variable, but practically all the observations were made near the epoch of light-maximum. The average radial velocity is given as 29 km. per sec. C. P. B.

1006. *Observations of Variable Stars.* **H. Shapley.** (Astrophys. J. 41. pp. 291–306, May, 1915. Mt. Wilson Solar Observatory, Contrib. No. 99.)—The paper consists of a collection of notes on various variable stars, chiefly in connection with the theory of eclipsing variables. Data are given concerning the stars U Pegasi, O Persei, R Canis Majoris, AE Cygni, and an estimate of the number of naked-eye variables of different classes. C. P. B.

1007. *Comparison of Harvard and Mount Wilson Magnitude Scales.* **F. H. Seares.** (Astrophys. J. 41. pp. 259–290, May, 1915. Mt. Wilson

Solar Observatory, Contrib. No. 98.)—Examination of the Harvard and Mount Wilson results on stellar photometry of the Polar sequence reveals a satisfactory agreement between the tenth and fifteenth magnitudes so far as parallelisms of the scales is concerned. There are, however, differences for brighter and fainter stars which introduce some uncertainty in the treatment of the results for statistical purposes. The present paper contains details of various critical comparisons of the two series of determinations. The Mount Wilson colour-indices afford the possibility of investigating the influence of colour, and it is found that a small correction is necessary, which would diminish to some extent the divergence between the two systems. The divergence of the scales for the faint stars is traced partly to the neglect to introduce a distance-correction in reducing the Mount Wilson plates for the Harvard scale. C. P. B.

1008. *Atmospheric Dispersion and Diameter of Star Images.* **S. Chevalier.** (Comptes Rendus, 160. pp. 472–475, April 12, 1915.)—Past experience with solar photographs has shown that the vertical diam. of a celestial body may be slightly augmented by the action of atmospheric dispersion [Abs. 632 (1914)]. The investigation has been continued by making a long series of photographs of the planet Jupiter, arranging that the axis of the planet was inclined at a certain angle to the vertical at the time of exposure. The coefficient of atmospheric dispersion adopted is practically as before, 0·17″. C. P. B.

1009. *Instrumental Undulation of Star Images.* **G. Bigourdan.** (Comptes Rendus, 160. pp. 415–419, April 6, 1915.)—A series of notes on the question of the various undulations of the images of celestial objects, as seen with a telescope, which generally come under the heading of the characteristic known to observers as the *seeing*. This is usually expressed on a numerical scale, which gives some idea of the steadiness of the air during observation. The undulations increase with the distance of the body observed from the zenith, and are generally at a minimum somewhere about the time of sunset, possibly owing to there being a period of atmospheric equilibrium. There is some evidence also of an annual variation, but it is more difficult to assign the best period, and this is probably different for different localities. The images are usually steadiest when an east wind is blowing. These points must be kept in mind in the selection of an observing station for astronomical work. C. P. B.

1010. *Small Displacements of Star Images.* **J. C. Solá.** (Comptes Rendus, 160. pp. 387–388, March 29, 1915.)—In the course of a series of photographs of various regions of the sky with an equatorially mounted camera of 16 cm. focal length, the author has detected on the plates certain small displacements of a few stars relative to others near by, the movement being of the order of 2 to 4 seconds of arc. There appears to be no evidence of periodicity, the movements are not always in the same direction, and the stars showing them are nearly all faint, from 11 to 12 magnitude. It is suggested that they may be due to effects of local refraction produced by the passage through space of drifting obscure gases, obstructing the light of various stars as they pass across the line of sight. C. P. B.

1011. *Orbital Characteristics of Cepheid-Geminid Variables.* **C. D. Perrine.** (Astrophys. J. 41. pp. 307–314, May, 1915.)—Investigation of the elements of the Cepheid-Geminid variables leads to the recognition of several notable characteristics: generally large orbital eccentricities, very small proper motions, common spectral condition, classes F–G, strong preference for the Milky Way. There appears also to be some relation between the eccentricities and the angles of periastron. It is suggested that the actual variation of light is caused chiefly by changes in the light of the secondary due to disturbances in the part of its orbit near periastron, similar in principle to the brightening of a comet near perihelion. C. P. B.

1012. *Relations between Radial Velocity, Proper Motion, Magnitude, and Spectral Class.* **C. D. Perrine.** (Astrophys. J. 41. pp. 315–322, May, 1915.)—During an investigation of the distribution of the nebulæ and variable stars some peculiarities were suspected in the distribution and velocities of the stars of class B with reference to magnitude. Attention is called to the apparent contradiction between the radial velocities and proper motions so far as dependence on magnitude is concerned—the velocities appearing to increase with decreasing brightness, whereas the proper motions decrease. There appears to be a relation in general between the brightness and spectral type, the brighter stars predominating in the early classes, B, B_1, B_2, while the fainter stars are more in classes B_3, B_5, B_{8-9}. The conclusions afford additional support to the discoveries by Campbell, Kapteyn, Frost, and Adams of the variation of inherent velocity of the stars with supposed increasing age. It further tends to place the early velocity stars close to zero and to show that the velocities increase regularly.
C. P. B.

1013. *Abnormal Variability of Mira Ceti.* **A. Bemporad.** (Soc. Spettroscop. Ital., Mem. 4. Ser. 2. March, 1915. Nature, 95. p. 405, June 10, 1915. Abstract.)—Observations of the recent abnormal maximum of this variable show that it only reached to 4·2 magnitude, while at previous maxima it had been as bright as 3·3–3·6. C. P. B.

1014. *Great Nebulous Region near ο Persei.* **E. E. Barnard.** (Astrophys. J. 41. pp. 253–258, May, 1915.)—By giving an exposure of 6h. 41m. with the Bruce portrait lens camera at the Yerkes Observatory, a photograph of the region round ο Persei has been obtained showing a most extensive area of nebulosity. The object is practically coincident in location with a well-known region where faint stars are conspicuously absent, and the suggestion is made that the nebulous matter may be obscuring the light from the fainter stars beyond. The nebulosity extends over about 8° east to west, and 3° north to south, its brightest portion being about 2° in diam. Detailed notes are given of the numerous points of interest in the structure of the mass, attention being drawn to the fact that the well-known nebulous region surrounding the Pleiades star cluster appears to be connected with the region. C. P. B.

1015. *Spectroscopic Analysis of Meteorites.* **J. Lunt.** (S. African J. of Science, 11. No. 7, April, 1915. Nature, 95. p. 354, May 27, 1915. Abstract.)—Spark spectra of various meteorites were photographed with a 4-prism spectrograph at the Cape Observatory, with the object of endeavouring to detect any elements which might have escaped detection in the previous chemical analysis, and to compare the composition of the N'Kandhla, Great Namaqualand, Matatiele, Hex River, and Goamus meteorites. Important differences were recorded in comparison with the chemical analyses. C. P. B.

LIGHT.

1016. *New Telephotographic Appliances.* **O. Wheeler.** (Phot. J. 55. pp. 200–204; Disc., 204–207, May, 1915.)—The first apparatus described is a combined tilting table, lens support and panorama adjustment. The advantage of the arrangement lies not only in the rigidity of the tilting adjustment, but in the manner in which the lens support will move in and out with the tele-mount. The camera at full extension on this table is absolutely firm. The second appliance is an improved and extended form of the "Dodo" lens. The principle on which the "Dodo" is based is the fact that by compounding negative elements of suitable length it is not only possible to get focal lengths shorter than that of any tele-negative on the market, but the compounding produces in some cases a positive advantage in the way of increased covering power. The special feature of the little system now introduced in conjunction with this is a camera-scale or indicator, showing at a glance, not only what camera extension is necessary for any given magnification, but also which lenses or combination of lenses should be used for that particular degree of enlargement. The third apparatus is a little diaphragm hood, the essential novelty of which is that it can be used to a marked aperture which has been found by experiment to be the one which can most profitably be used at a given magnification, and using a given stop on the positive lens. A. E. G.

1017. *Absorption, Reflection, and Dispersion Constants of Quartz.* **W. W. Coblentz.** (Bureau of Standards, Bull. 11. No. 3. pp. 471–481, May 10, 1915.)—This paper gives quantitative data on the absorption, reflection, and dispersion of quartz, extending from the ultra-violet to 3μ in the infra-red. The data may be used in determining spectral energy curves. Quartz is practically transparent from the ultra-violet to $1{\cdot}8\mu$. It begins to absorb strongly beyond $1{\cdot}8\mu$, and tabulated data are given for eliminating the effect of this absorption in a quartz prism. The results show that (within the errors of observation) in unpolarised light, the transmission is not affected by the direction in which the radiations pass through the material with respect to the optic axis. A. W.

1018. *Effective Wave-length of Colour Filters.* **M. Pirani** and **W. W. Loebe.** (Deutsch. Phys. Gesell., Verh. 17. 3. pp. 47–62, Feb. 15, 1915.)—The effective wave-length of a colour filter does not in general coincide with its transmission maximum. In the present paper methods of estimating the effective wave-length are described. The values obtained by calculation from the transmission curve are in good agreement with spectrophotometric measurements for the filters designated monochromatic, so long as the effective wave-length lies between 470 and 640 $\mu\mu$; a monochromatic filter is taken as one which at a distance of $\pm$ 50 $\mu\mu$ from the transmission maximum has a transmission power not more than 1 % of the max. value. The most accurate values and the best agreement are obtained with filters whose effective wave-length lies in the yellow-green part of the spectrum, where the eye has its greatest sensitiveness. With filters limited on one side physically and on the other physiologically, as in the case of deep-red and deep-blue filters, the agreement between calculation and experiment is not so good. Difficulties also arise in the case of filters with a broad transmission region. The effective wave-length of filters showing several sharp maxima and minima can only be estimated when the highest maximum is at least 10 times as great as the next. A. W.

1019. *The Tyndall Phenomenon in Liquids.* **W. Kangro.** (Zeitschr. Phys. Chem. 87. pp. 257–292, 1914.)—Light striking particles suspended in any medium enters those particles, or is deflected or diffracted. In the latter case it is polarised, completely in a plane at right angles to the incident light (Rayleigh); this can be tested by means of photographic photometry. Applying this test to liquids supposed to have been made "optically empty" by allowing precipitates produced in the liquids to carry down all the suspended particles in them (W. Spring and others), the author finds that optically empty liquids cannot be prepared in this way. The ordinary methods are insufficiently definite, moreover, to place any reliance on differential observations. A modification of the distillation apparatus for preparing conductivity water, which R. Bourdillon has described [Abs. 1559 (1913)], seems promising, however, though absolute optical homogeneity was not realised. H. B.

1020. *The "Braun Dispersion-grating."* **A. Ungerer.** (Ann. d. Physik, 46. 1. pp. 130–146, Dec. 29, 1914. Dissertation, Strasburg.)—In 1886 Kundt observed with a metallic mirror, formed by kathodic sputtering, a phenomenon which he described as double refraction, but for which he could find no satisfactory explanation. Braun [see Abs. 978 (1905)], in considering the same phenomenon, conceives it as an optical analogue of the Hertzian "grating effect." The only assumption made is "that the radial orientation of the metallic particles, in spite of the fact that they appear as a homogeneous layer in Kundt's researches, behave nevertheless like a Hertzian grating." According to this view it is to be expected that if such a film is examined in polarised light, without the presence of an analyser, it will appear brighter or darker according as the electric vector is in the radial or tangential direction. The author has investigated this question experimentally, using mirrors, produced by kathodic sputtering, of the metals Pt, Ni, Fe, Ag, Cu, and Au. After subjecting these films to various treatments the most suitable conditions for the restoration of the Braun-effect have been examined. The phase-difference between the two components has been measured in a large number of cases, and it has been found that in all cases the component vibrating parallel to the lines of the "grating" is accelerated relative to the other component—this is in accordance with the grating theory.

Various specimens have been oxidised, by heating in oxygen, and subsequently reduced in hydrogen. It was found that the grating action, which by oxidation had almost disappeared, reappeared more or less strongly after reduction to the metallic state; in particular, with a good film of Ni the grating effect almost regains its initial strength after the above treatment.

When the metallic deposit is dissolved from a glass surface by means of hydrofluoric acid, any undissolved portion shows the grating action unchanged. By treating in this way with hydrofluoric acid it is shown to be possible to transfer a copy of the grating to the glass plate: the metal layer so treated is easily dissolved and the glass plate can be silvered; this silver mirror shows excellent grating action.

All the above observations confirm the view advanced by Braun, that the optical phenomenon of metallic dispersion can only be explained as the analogue of the Hertzian-grating effect. A. B. W.

1021. *Twisting Impulse of Light.* **M. Abraham.** (Phys. Zeitschr. 15. pp. 914–918, Dec. 1, 1914.)—Mathematical treatment of the hypothesis of J. H. Poynting as to the turning impulse of circularly polarised light about an axis parallel to the rays. [See Abstract No. 1672 (1909).] E. H. B.

1022. *Scattering and Regular Reflection of Light by Gas Molecules.* II. **C. V. Burton.** (Phil. Mag. 29. pp. 87–105, July, 1915.)—A mathematical continuation of the first part on this subject [see Abs. 845 (1915)]. It is concluded as reasonable to suppose that, when resonance radiation, due to a single resonant frequency, is emitted from an attenuated vapour, the law of general enfeeblement of that radiation, when passing through the same vapour, depends only on the type and number per $cm.^3$ of molecular resonators. E. H. B.

1023. *Selective Reflection of Solutions of Nitrides.* **A. K. Ångström.** (Zeitschr. Phys. Chem. 86. pp. 525–528, 1914.)—According to Drude the absorption in the ultra-violet is due to particles of the size of electrons, and in the infra-red to particles of the order of molecules. The phenomena have been studied after Rubens and Wood chiefly by Coblentz. To investigate the selective reflection of saturated solutions of the nitrides of Na, K, NH_4, Ca, Ba, the author makes use of a spectroscope and a Nichols radiometer. Within the interval $1\,\mu$ to $10\,\mu$ there is only one position of selective refraction, near $4{\cdot}9\,\mu$; this, however, was not shown by the $Ca(N_3)_2$ and $Ba(N_3)_2$, probably because these nitride solutions are of low concentration even when saturated. The strong absorption band between $4{\cdot}6\,\mu$ and $4{\cdot}8\,\mu$ seems to be characteristic of the group N_3. H. B.

1024. *Measurement of Refractive Indices of Birefracting Minerals in Polarised Light.* **F. E. Wright.** (Washington Acad. Sci., J. 4. pp. 534–542, Nov. 19, 1914.)—Gives a number of formulæ useful in petrographic microscope work, and shows how these can be applied. L. H. W.

1025. *Covellite: Singular Case of Chromatic Reflection.* **H. E. Merwin.** (Washington Acad. Sci., J. 5. pp. 341–344, May 19, 1915.)—Covellite, crystalline cupric sulphide, in finest powder is very dark blue; brilliant crystal surfaces or polished plates, whether obliquely or vertically illuminated, are lighter, and vary noticeably in colour with differences in crystallographic section. In obliquely incident daylight a plate, parallel to the cleavage, immersed in alcohol (refractive index $n = 1{\cdot}36$) appears brilliant purple, in benzene ($n = 1{\cdot}50$) it appears reddish purple, and in methylene iodide ($n = 1{\cdot}74$) it appears red. A plate perpendicular to the cleavage changes only to purple in methylene iodide. The optical properties of this substance were investigated, using some crystals artificially prepared. Absorption is so strong that the colour of covellite even in the finest powder is due to light reflected directly from the surfaces of grains. Yet differences in absorption of different colours are not sufficient to cause marked differences in the reflection of these colours. Hence the explanation of the colour effects already described is to be sought for in the refractive index and the reflective power. The refractive index was found to vary from 1·00 at wave-length 635 $\mu\mu$ to 1·97 at wave-length 505 $\mu\mu$, and this allows a satisfactory explanation of the colour effects to be given. A. W.

1026. *The Unit of Candle-power in White Light.* **C. C. Paterson** and **B. P. Dudding.** (Phys. Soc., Proc. 27. pp. 263–286; Disc., 286–290, April, 1915. Electrician, 75. pp. 251–253, May 21, 1915. Abstract. Phil. Mag. 29. pp. 63–86, July, 1915.)—The absolute value of the unit of candle-power for white light has been re-determined from the pentane lamp, and found to agree with the value previously obtained within 0·1%. The corrections for humidity and barometic pressure have also been checked, and found to agree with previous determinations within various limits. But a relation between humidity and temperature seems to exist, and this may acount for a difference in the humidity constants as obtained in London and Washington. Reference is made to difficulties arising through small differences in the colour of light yielded by so-called "white light" standards of light. In order to diminish errors of observation thus caused, experiments were made on a series of 6 sets of graduated electric glow-lamps operating as sub-standards. The efficiencies of these lamps were so graded that the colour of the light varied from that of the pentane lamp to that of a tungsten lamp working at 1·5 watts per candle. Differences in the values obtained by different observers in the process of stepping from one colour to the next are compared with those obtained by the direct comparison of the first and last sets of sub-standards. It is shown that the uncertainties arising through such differences in colour are not great, the probable error being of the order of 0·25%.

In the *discussion*, **A. P. Trotter** emphasised the importance of knowing the temperature at which the results in America were obtained; this might enable the temperature coefficient to be determined. The discrepancy in the values at Teddington and Washington was probably due to the difference in the degree of saturation of the atmosphere. **J. S. Dow** and **A. Campbell** said that the personal errors resulting with the cascade method did not appear much less than those occurring with direct comparison. The former also suggested that small discrepancies might be caused by altering the position of the telescope in the Lummer-Brodhun photometer. **T. Smith** suggested that the chromatic aberration of the eye might have some effect. **T. Guild** advocated experiments on a number of observers with a view to the application of a physical method related to the normal eye. **C. C. Paterson,** in reply, pointed out the difficulty of determining the temperature coefficient in regard to humidity for the pentane lamp. The cascade method was only suggested as a means of standardising sub-standards whose light differed in colour, in a central laboratory. The effect of altering the telescope of the Lummer-Brodhun photometer would be inappreciable in these experiments, and the illumination was high enough to preclude any possibility of the Purkinje-effect. J. S. D.

1027. *Total Luminous Efficiencies of Present-day Illuminants.* **H. E. Ives.** (Phys. Rev. 5. pp. 390–394, May, 1915.)—The lumen has been found to be 0·00162 watt. The "efficiency" of any illuminant in lumens per watt can, by the use of this constant, be translated into watts of luminous flux per watt of power input. This is a simple fraction, on a scale of efficiency in which the value of the most efficient possible light-source is unity. The standard carbon glow-lamp has an efficiency in the present practical units of 2·59 lumens per watt. Now 2·59 × 0·00162 = 0·0042, the ratio of luminous output to power input expressed in the same units, or the total luminous efficiency. If the watt is adopted as the unit of luminous flux, as the author has suggested, the ratio of output to input as measured is at once the efficiency. A table of total luminous efficiencies is appended which has been prepared from data collected from a number of sources. I. W.

1028. *Flicker Photometer Measurements with a Monochromatic Green Solution.* **H. E. Ives** and **E. F. Kingsbury.** (Phys. Rev. 5. pp. 220–235, March, 1915.)—For some experiments on the mechanical equivalent of light a solution was required which, used with a "4-watt" carbon lamp, would transmit light which matched that of the green line in the Hg spectrum, 0·5461μ. Such a solution was furnished by a mixture of potassium dichromate 2·5 gm., cupric chloride 265 gm., nitric acid (sp. gr. 1·05) 26·5 cm.^{3}; water to one litre. Directions are given for the preparation of the solution which is used in a cell having a thickness of 25 mm. A curve is given illustrating the effect of change of temperature on the transmission. With a view to determining the transmission of the solution at a standard temperature of 20° tests were made with a flicker photometer, in which 61 observers took part. It is believed that none of these were colour-blind; nevertheless, individuals vary from the mean as much as 16% above and 29% below. The transmission thus determined is found to be 0·0437 as compared with clear water. Repeat experiments gave consistent results to within 1%, and the above result is believed to represent a close approach to the transmission for the normal eye. It is important to note that a large number of observers must be employed to obtain this result. The fact that the readings of groups of observers were close together, but nevertheless far removed from the mean, shows that in heterochromatic work agreement in the readings of a few observers does not necessarily imply that the readings are correct. J. S. D.

1029. *Effect of Ultra-violet Light on the Eye.* **W. E. Burge.** (El. World, 65. pp. 912–914, April 10, 1915.)—Cataract is known to be prevalent among glass-blowers, in the tropics, and among elderly people. The most plausible explanation of the opacity of the eye-lens is that it is due to coagulation of the lens protein, just as egg-white and other proteins may lose their transparency when acted on by certain chemicals or exposed to heat. To test the possible effect of radiation in this respect, excised pig and ox lenses were exposed to an electric furnace, being almost submerged in open vessels containing egg-white, blood serum, aqueous and vitreous humour respectively. When the exposed lenses and media were placed in a tank of running water (with the mouth of vessel slightly above its surface), even an exposure of 100 hours failed to produce any opacity. In other cases in which the media were placed very close to the furnace opacity occurred, but the temperature of the lens had risen to 80°, and the conclusion was drawn that this, and not the red or the infra-red radiation, had caused the coagulation. Exposures to the visible spectrum gave rise to similar results. The filament of a 2000-c.p. gas-filled lamp was focused on the lenses, but exposures for as much as 100 hours gave rise to no opacity. On the other hand, opacity could be produced in a few minutes by focusing the image of the sun on the lenses; but in this case also the rise in temperature was sufficient to account for the coagulation. Similar experiments regarding the effect of ultra-violet light were made. A Cooper Hewitt (2500-c.p.) quartz-tube mercury lamp was used. At a distance of 5 cm. below the tube coagulation of egg-white and blood-serum occurred after 20 minutes' exposure, but the lenses were unaffected even after 100 hours, the aqueous humour was still clear, and the vitreous humour only slightly clouded. This is interesting, since practically all other protein substances can be coagulated by ultra-violet light. Now the author, by the analysis of cataractous eyes obtained from India, has found a great increase over the normal in the percentage present of certain chemicals. For example, eyes from India contained appreciable amounts of silicates of potassium and calcium; and in other cases various salts of these metals and of magnesium have been found. The presence of these materials therefore seems to render the protein liable to coagulation. This was confirmed by the author, who repeated the exposure to ultra-violet light on lenses immersed in solutions of magnesium chloride, sodium silicate, and dextrose. Turbidity and even total opacity could be produced in these circumstances. The conclusion would seem to be that certain conditions of health, which give rise to abnormal quantities of such materials (those suffering from diabetes, for example, accumulate increased amounts of dextrose), also predispose the eyes to cataract. There are thus two distinct factors: (1) the presence of these substances which modify the lens-protein, and (2) continual exposure to rays of short wave-length, by which the modified protein may be precipitated. The effective region in the spectrum of the quartz lamp appears to be from 265 $\mu\mu$ to 302 $\mu\mu$, the former being the point of greatest activity. J. S. D.

1030. *Thio-Indoxyl Development and the Theory of the Latent Image.* E. **Crowther.** (Phot. J. 55. pp. 186–197; Disc., 197–199, May, 1915.)—The results of these experiments are entirely at variance with those of Homolka. He stated that indoxyl and thio-indoxyl developers would yield normal negative results with very prolonged exposures, and that if the images be separated by suitable treatment and examined it would be found that with exposures which had been sufficient to cause reversal the silver image was reversed, the colour image being unreversed. The method of preparing the thio-indoxyl solution is described. The solution so prepared when used at a temperature of 65° F. develops an exposed plate slowly, the first appearance of the image occurring 4 or 5 mins. after pouring on the developer. At the end of 15 or 20 mins. a fair density has been developed. Two Barnet S.S. Ortho plates, backed, were exposed behind the Chapman Jones test-plate for 20 mins. at 12 in. from an illuminated inverted gas mantle, and after washing off the backing they were developed for 15 mins. at 65° F. with the thio-indoxyl developer. After washing, fixing, and drying the results are examined. One of the results shows the normal negative stage and the reverse stage. In order to investigate the question of the reversal or non-reversal of the coloured thio-indigo image, the silver is dissolved from the other plate, and then it is seen that the colour image is reversed to exactly the same amount as the silver image. The results obtained agree in all respects with a chemical interpretation of the reactions which yield the latent image—the light acting, as Baly has pointed out, simply as a catalyser by opening up closed force-fields. The theory now advanced is as follows:—Light of a frequency to which the silver halide is sensitive instigates a splitting-up of the halide into silver and halogen. The former can act as an electrical nucleus round which development may proceed, or, given suitable conditions, may be re-halogenised by the latter, or it may, by sufficiently gross exposure, be a component of a printed-out image. The halogen enters into chemical reaction with the gelatine, and is thus removed from the sphere of action. If no gelatine or other halogen accommodating agent be present, the halogen must perforce be liberated as such before it is removed from the system, and the reaction can continue. That gelatine is similar to the developers so far as its halogen accommodation is concerned—similar, but of very inferior power, is evinced by the fact that over-ripening of a gelatine bromide emulsion will lead to decomposition of the halide, visible in bad cases before development, and, in any case, rendered evident by so-called chemical fogging. The gelatine-bromine complex is, according to the theory under consideration, attacked by the developer at the same time as the main development proceeds, and the products of the reaction are responsible for the reversal phenomenon. A. E. G.

1031. *Electro-photography.* **A. Palme.** (Elektrot. u. Maschinenbau, 32. p. 598, July 12, 1914.)—The method adopted for obtaining photographic impressions of coins, etc., is as follows: An ordinary photographic plate is placed film side up on a sheet of metal; the object to be photographed is then placed in contact with the emulsion. Wires from the poles of a high-tension transformer giving a minimum p.d. of 5000 volts are connected with the coin and metal plate respectively. The explanation of the results obtained appears to be that a glow discharge occurs between the two metallics discs which are separated by the glass of the photographic plate, and that the generation of ultra-violet rays accompanies this discharge. These rays decompose the silver bromide. Those parts nearest are subjected to strongest action, and *vice versa*, hence a half-tone image results. A. E. G.

1032. *Orthochromatic Photography by Artificial Light.* **G. C. Trabacchi.** (N. Cimento, 9. pp. 140–146, Jan.–Feb., 1915.)—The author shows, by means of spectrographic diagrams, the advantages of orthochromatic photography by artificial light. Modification of the latter is possible, whereas the emulsion of the plate cannot be changed. Comparison of the diagrams relating to orthochromatic plates with those for ordinary plates shows that when non-orthochromatic plates are used the greater part of the radiations furnished by artificial light are not utilised. T. H. P.

1033. *A Method of Automatic Exposure and Development.* **C. Gravier.** (Phot. J. 55. pp. 234–238; Disc., 238–241, June, 1915.)—The method starts from the standpoint that photographic apparatus and material is now so well standardised that, having once chosen the lens, shutter, plate, and developer one is going to use, the only thing that remains is to standardise the method of using them. By preference a lens working at $f/4{\cdot}5$ should be fitted with a reliable shutter marked with the speeds at which it can be set. The plate chosen should be backed, and of a "rapid" type for summer work, and "extra rapid" for winter work. A method of determining the suitability of the plate is suggested; this is based on what is described as an irrefutable fact that the developer should not, during the time necessary for development, fog a sensitive surface that has not been exposed to light. The developer recommended is Adurol-Hauff, and as alternative hydroquinone. Adurol requires only 5 minutes for development, whilst hydroquinone requires 10 minutes under this system. A hydroquinone metol or acid pyro formula can be used equally well. A further step is to make a trial of the shutter (which is explained). For instantaneous work a single speed is adopted for all subjects in summer-time of $\frac{1}{40}$ sec., which is the speed adopted by kinema operators. The largest diaphragms are always used and a latitude of 20 times the exposure is obtained without getting unprintable negatives. For other degrees of lighting the diaphragms may be varied, whilst maintaining the shutter speed the same. For instance, f/11·8 for exposures in the sun, and f/14·5 for exposures in well-lighted shade: the time of development always remains the same. To avoid errors in the direction of under-exposure when the light is not good enough for instantaneous work, a very simple actinometer is used. A special piece of apparatus is proposed for those who have no dark-room or do not want to use one. A further departure from the orthodox practice is, that it is not necessary to fix the negatives. An exposure table is given. During the *discussion* the opinion was expressed that the system failed in the fixed standard of $\frac{1}{40}$ sec. exposure, the absence of any temperature limit for the developer, and the printing from plates which have not been fixed.

A. E. G.

1034. *Law of Dispersion in Prismatic Spectra.* **Salet.** (Comptes Rendus, 160. p. 715, May 31, 1915.)—Up to the present no simple formula has been given connecting the wave-length of a line with its position in the prismatic spectrum, and giving results of great accuracy. Cornu's formula only represents the real curve of a spectrograph for small intervals, and the more complicated formulæ, which derive empiric relations between the refractive index and the wave-length, introduce many difficulties in calculation without being rigorously exact. The following formula has been found to give results of great accuracy for the whole length of the dispersion curve, the errors being no greater than the errors of observation in measuring a single line: $\lambda = a \tan (bl + c) + d$. Here l is the distance of the line of wave-length λ from some fixed point, and a, b, c, and d are constants. The values of $\lambda' = d\lambda/dl$ all along the curve are very well represented by a formula of the form $\lambda' = A\lambda^2 + B\lambda + C$. The mean values of A, B, and C were determined by the method of least squares. It is generally sufficient to find approximate values of A, B, and C, and thence of a, b, c, and so to calculate three Cornu formulæ for three different regions of the curve. The quantity $B^2 - 4AC$ is negative. It is of interest to note that in the Cornu formula $(l - l_0)(\lambda - \lambda_0) = k$, the derived function λ' is also an expression of the second degree in λ, but having equal roots. Cornu's formula can thus be considered as a particular case of the more general formula which has now been obtained.

A. W.

1035. *Reduction Formula for Prismatic Spectra.* **M. Hamy.** (Comptes Rendus, 160. pp. 701–704, May 31, 1915.)—The study of the plates obtained with the stellar spectrograph of the Paris Observatory has led Salet to discover that the wave-length λ of any line can be expressed, with a high degree of approximation, by the formula $\lambda - \lambda_0 = h \tan k(l - l_0)$, where λ_0, l_0, h, k are constants and l is the reading of the micrometer in the measuring apparatus [see preceding Abs.]. Another formula has now been obtained, which gives results of the same degree of accuracy as the formula of Salet, but is simpler to use. The formula is $\lambda - \lambda_0 = (l - l_1)/[A_0 + A_1(l - l_1) + A_2(l - l_1)^2]$, where A_0, A_1, A_2 are constants, and A_2 is very small. This formula is a particular case of one having for denominator $[A_0 + A_1(l - l_1) + \dots + A_n(l - l_1)^n]$; this more complete formula could be used to determine the positions of the lines of a spectrum whose limits are a long way apart in the wave-length scale.

A. W.

1036. *Spectrum of Gadolinium.* **E. Paulson.** (Phys. Zeitschr. 16. pp. 7–8, Jan. 1, 1915.)—Regularities in the spectra of lanthanum, scandium, etc., have previously been observed by the author [Abs. 809 (1915)]. It is now shown that similar regularities exist in the spectrum of gadolinium. The lines of the spectrum are arranged in a number of series with constant frequency-differences. A. W

1037. *System of Wave-numbers in the Spectrum of Scandium.* **E. Paulson.** (Phys. Zeitschr. 15. pp. 892–894, Nov. 1, 1914.)—A continuation of work on the analysis of the spectrum lines of rare-earth metals. The author has shown that the spectrum lines of these elements can be arranged into varying numbers of groups A, B, C, etc., such that there are constant frequency-differences, D_1, D_2, D_3, etc., between corresponding lines in the consecutive groups, A, B, C, etc. In this paper scandium and lanthanum are investigated. The results are best exhibited in the following table :—

Element.	D_1.	D_2.	D_3.	D_4.	D_5.	D_6.
Yttrium	1846·91	404·78	204·96	—	—	—
Lutetium	5571·42	1764·33	2217·03	—	—	—
Scandium ...	158·77	315·41	103·55	139·98	1581·10	81·94
Lanthanum ...	2977·86	659·00	696·80	879·18	1016·32	—

It is pointed out that, in general, the D's increase with the atomic weight of the element. Arc lines to the number of 440 have been measured in the scandium spectrum, and 208 of the strongest of these are included in tables which appear in the paper. It ought to be mentioned that often individual lines in the various groups are unrecorded and that in the case of scandium there appear several lines which do not fit into the above system. Constant frequency-differences, of magnitudes differing from those shown above, can, however, be obtained by suitable arrangement of these abnormal lines.

C. S. G.

1038. *Character of the Red Spectrum of Argon.* **E. Paulson.** (Phys. Zeitschr. 15. pp. 831–833, Oct. 1, 1914.)—Kayser first, and Rydberg later, showed that the blue spectrum (from 4702–3319 Å.U.) of argon exhibited a certain regularity. Lines in this region could be analysed into four groups, such that constant frequency-differences between corresponding lines in the groups were shown : between Group I. (redward side) and Group II., 846·47 ; between Groups II. and III., 803·21 ; and between III. and IV., 607·03 units. This regularity has now been shown to extend throughout the red region also. The measurements, which have not the accuracy of those of Kayser, have been made from λ4702 to about λ9600 Å.U., and show 36 sets of the four groups. The mean differences found were 847·71, 802·91, and 606·80. As in the older investigations, various sets are lacking in one or two members, but the first group, as before, contains the redmost lines. Again, in three sets the frequency-differences are of the right amount but the wrong way round. C. S. G.

1039. *Continuous Spectra of Gases.* **E. P. Lewis.** (Nature, 95. pp. 394–395, June 10, 1915.)—A continuous background has often been observed in the vacuum-tube spectra of various gases, usually in the visible regions, but in a few instances in the ultra-violet region. The author obtains such a background in the ultra-violet with a hydrogen tube by using a large 2-prism spectrograph and an uncondensed spark. Impurities are eliminated as a possible cause of this continuous background, whose extent seems only to be limited by the transparency of the quartz. If the phenomenon is to be attributed to molecular collisions, it ought to be best evidenced in the lighter gases, and this has been found to be the case. Under similar conditions helium gave a spectrum about half as strong as hydrogen; neon one-third as strong; with nitrogen, krypton, and xenon no continuous spectrum was obtained. The best conditions for its production in hydrogen are attained by using, end-on, a quartz-windowed tube, 5–10 mm. diam. and 80 cm. long at a pressure of 5 mm. With such a tube as source, the absorption spectrum of benzene was photographed, taking only a 15-minute exposure. **J. Barnes.** (Ibid. p. 451, June 24, 1915.)—Barnes has noticed that the spectrum of the discharge between a Wehnelt kathode and an iron anode, with a discharge current of 1 to 2 amps., is rich in ultra-violet light. When the air in the bulb is exhausted as completely as possible by a Geryk pump only nitrogen bands and the Hg line λ2536 are observed, but on admitting hydrogen the continuous spectrum makes its appearance whilst the original spectrum is intensified. If the air is frozen out and the tube washed out with pure hydrogen only a continuous spectrum is obtained on passing the current. The pressure of hydrogen was about 2 mm. and the spectrum extended to λ2000 Å.U. The author ascribes the phenomenon to the bombardment of the hydrogen molecules by slow-moving electrons whose energy is not sufficient to produce ionisation in the hydrogen. C. S. G.

1040. *Radiation from an Electric Source.* **L. Silberstein.** (Phil. Mag. 29. pp. 163–178, July, 1915.)—A continuation of previous work [Abs. 850 (1915)]. The author has now found that his radiation formula will represent all the lines of the hydrogen series if γ is taken equal to λB, *i.e.* Balmer's theoretical limit, and a second "free period," or convergence point, is introduced in the far infra-red. Numerical results will be given later. The present paper develops the theory further, particular attention being paid to specific heat curves; the permittivity is first taken as unity and then large values are considered, the source in this case being reduced to molecular dimensions. A. W.

1041. *Spectra of Hydrogen and Helium.* **N. Bohr.** (Nature, 95. pp. 6–7, March 4, 1915.)—The author contests Nicholson's argument [Abs. 695 (1915)] that Evans's results cannot be used to discriminate between the different theoretical interpretations of the spectra in question. For the new series as well as the Pickeney series can be deduced from the 4686-series on the general principle of the combination of spectral lines. An interesting discussion is given of some aspects of the problem. **J. W. Nicholson** (Ibid. p. 33, March 11, 1915). Nicholson points out that Bohr's interesting discussion does not meet the specific objection raised by him, which still holds good. G. W. DE T.

1042. *Series Spectra of Hydrogen and Atomic Structure.* **N. Bohr.** (Phil. Mag. 29. pp. 332–335, Feb., 1915.)—The author points out that objection may be taken to the validity of H. S. Allen's calculations [Abs. 1088 (1915)]. Moreover, assumptions inconsistent with the theory adopted are made in order to account for Curtis's observation of a small systematic deviation of the "centre of gravity" of the hydrogen lines from the position calculated by Balmer's law [Abs. 1881 (1914)]. He further points out that the observed doubling of the H-lines is not yet accounted for, and the separation of their components is much greater than the deviations from Balmer's law, and the components are of unequal intensity. Until this is theoretically accounted for it is difficult to assign a meaning to measurements of the "centre of gravity" of the lines. G. W. de T.

1043. *Lorentz's Theory of Long-wave Radiation.* **G. H. Livens.** (Phil. Mag. 29. pp. 158–173, Jan., 1915.)—Lorentz's form of radiation theory, which regards the radiation from a thin metallic plate as arising from the motion of the electrons within the plate, involves only principles which are well established by independent theory and experiment, and will probably therefore always retain its position as a deciding factor in the general theory of the subject. The final formula, identical with the Rayleigh-Jeans formula, is based mainly on the two assumptions that the period of the radiation considered is long compared with the interval of time between two consecutive collisions of an electron with an atom and that this latter interval is also long compared with the time of duration of a collision. These assumptions naturally restrict the analysis to long waves, but Lorentz has expressed the opinion that the same formula would be obtained for all values if only the difficulties of the analysis could be overcome. The author here obtained a formula, concluded to be practically identical with the Rayleigh-Jeans formula, and applicable to all parts of the spectrum, on the single assumption that the duration of the impact of an electron with an atom is always negligibly small. Therefore, for all practical purposes the complete radiation formula applicable all along the spectrum is the usual Rayleigh-Jeans formula, $F(\lambda,T)=8\pi m u_m^2/\lambda^4$. But, physically, this is applicable only in the ultra-red part of the spectrum. This conclusion is, mathematically and physically, absurd. Now it is difficult, if not impossible, to indicate any steps in the analysis open to question. Yet the final result is inconsistent with the preliminary assumptions, and therefore apparently a contradiction in terms. For the Fourier series initially assumed, which can have no meaning unless convergent, ultimately turns out to be divergent. Turning to the physical basis of the theory for an explanation, the attempt is facilitated by the reduction from two initial assumptions to one. We have merely assumed that the duration of every collision of an electron with an atom is vanishingly small compared with the other periods involved in our analysis, and so long as this is justified the result must be correct. But in actual practice it is justified only when all the other times involved are large compared with the usual intramolecular periods, that is to say, only in the extreme ultra-red region of the spectrum. As soon as the encounters between electrons and atoms are long enough compared with the period of the light considered, the effect of the collision will begin to modify the radiation formula, a conclusion already drawn by J. J. Thomson. It is now no longer surprising that a divergent series is obtained in the expression for the total energy; in fact, the shorter the collision the farther up the spectrum does the agreement between theory and practice hold, but then the greater is the total energy. G. W. de T.

1044. *Polarisation of the Light emitted by Canal Rays.* **J. Stark** and **H. Lunelund.** (Bayer. Akad. Wiss., Ber. July, 4, 1914. Ann. d. Physik, 46. 1. pp. 68–84, Dec. 29, 1914.)—It was known that the light emitted by hydrogen canal-rays is partially polarised. The object of the present experiments is to separate the light into its parts, (*a*) that producing the band lines, (*b*) that producing the stationary series lines, (*c*) that producing the moving or displaced series lines, and to investigate each for its state of polarisation. The method used was to examine the light transversally to the tube, split it up by a spectroscope or grating and to interpose a Wollaston plate. The relative intensity of the various lines on the photographic plate was estimated by a method given by Stark [see Abs. 1387 (1911)]. It was first shown that the band lines in the negative glow and in the canal-rays, as also the series lines in the negative glow, are unpolarised. It is easy to account for the unpolarised nature of the light from the negative glow, as the kathode rays have a variety of velocities, and there are secondary and scattered rays present due to collision with the gas molecules. To investigate the stationary and displaced series lines in the canal-rays some device must be made use of to separate them, as the lines are coincident when the tube is viewed transversally, there being then no Doppler-effect. The separate investigations were made possible by the fact that hydrogen canal-rays in pure hydrogen give a preponderance of displaced energy. There is a small proportion of stationary energy which cannot be altogether neglected. The stationary energy in hydrogen can be greatly strengthened by the introduction of traces of heavier gases. Thus for both cases, only approximate values of the state of polarisation are obtained. This is probably not a drawback, as the state of polarisation may be a function of the velocity of the canal rays, and there is a variety of velocities present. The result was obtained that the stationary energy is unpolarised, whilst the displaced energy is polarised to the extent of 20–85 % in favour of the oscillations parallel to the axis of velocity. The polarisation of the displaced lines is attributed to a probable connection between the movement of the canal-ray particles and the orientation of the electrons producing the series lines. The absence of polarisation in the stationary lines and band lines is probably due to collision between the canal-ray particles and the gas molecules, producing ionisation, and so destroying any orientation. J. R.

1045. *Resonance of Sodium Vapour in a Magnetic Field.* **R. J. Strutt.** (Nature, 95. p. 38, March 11, 1915.)—It is well known that dilute Na-vapour contained in a glass bulb emits resonance radiation where a soda flame is focused upon it. This resonance, the author finds, is diminished by the action of a magnetic field when the exciting flame contains little soda, but greatly increased when the flame is rich in soda. The tentative explanation suggested is as follows:—Each sodium line emitted by the resonating vapour is broadened by the Zeeman-effect. The flame poor in salt gives a narrow exciting line, and magnetic broadening throws a part of the resonating line off the exciting line, thus diminishing the light. Adding more salt to the flame makes each exciting line broader, and (it is provisionally assumed) reverses the middle of it. Thus magnetic broadening of the resonance line tends to bring the brightest parts of the exciting line into action, and increases the light. G. W. de T.

1046. *Magneto-optical Absorption Effect described by Zeeman and Winawer.* **W. Voigt** and **P. Scherrer.** (Phys. Zeitschr. 15. pp. 865–868, Nov. 1, 1914.)—By examining Na-vapour with circularly polarised light for the inverse Zeeman-effect in a direction very slightly inclined to the lines of force, Zeeman and Winawer had in general obtained only the absorption line corresponding to the longitudinal transmission. With very dense vapour a much finer line appeared on the other side, and this line was unpolarised. In the case of D_1 it was established by measurement that this line occupied the place of the p-component lying on the other side. For D_2 exact measurements were impossible. Finally, the new line was obtained when the transmission was in line with the field axis.

The authors point out the theoretical significance of this phenomenon and attribute it to the lack of homogeneity in the field which was used in the investigation mentioned. They show how, in such an arrangement, the s-component would be too weak by contrast to appear. Arrangements were set up with which their theoretical deductions were substantiated. [See Abs. 1429 (1910).] C. S. G.

1047. *Preston's Rule. The D Lines in Magnetic Fields.* **S. Popow.** (Phys. Zeitschr. 15. pp. 756–761, Aug. 15, 1914.)—An elaborate study of the separation of the D lines in magnetic fields was undertaken. The H and K lines of calcium were taken as standards. These were measured in the second, third, and fourth order in a field of 38·88 ± 0·5 % kilogauss. Diagrams and tables are given for the D lines. For weak fields the following results were obtained :—(i) The geometric centre of the perpendicular and parallel components of D_1 is common to both, while for the inner perpendicular components of D_2 the mean point is practically coincident with the position of the line in the absence of a magnetic field. (ii) The mean points of the parallel components of D_1 and D_2 are displaced about equal amounts. (iii) The mean point of the outer perpendicular components of D_2 is displaced about the same amount (a little more) as for the corresponding parallel components. These results are discussed in the light of the researches of various other investigators, including Voigt, Sommerfeld, and Paschen and Back [Abs. 1826, 1151, 419 (1913)]. A. W.

1048. *Zeeman-effect and Temperature.* **H. R. Woltjer.** (Phys. Zeitschr. 15. pp. 918–924, Dec. 1, 1914.)—Wood and Zeeman's method of obtaining fine absorption lines in the magnetic field was used in comparing the Zeeman-effect of the D lines at different temperatures (low—vacuum tube about 300° C. ; high—electric spark and oxy-acetylene flame). The distance of the components was not altered, but the relative intensity of the outer and inner perpendicular components of D_2 appeared to be.

The observations also showed the linkage of D_1 and D_2. J. M.

1049. *Fluorescence of Uranyl Salts caused by X-rays.* **F[rances] G. Wick.** (Phys. Rev. 5. pp. 418–425, May, 1915.)—An experimental investigation leading to the following conclusions :—(1) The fluorescence excited in uranyl salts by X-rays differs from that excited by light in intensity only. The greater absorption of these rays for light than for X-rays accounts for the difference in intensity of the fluorescence under the two sources. (2) The phosphorescence following excitation by light is less intense and of shorter duration than that excited by X-rays. The difference in penetration of the two kinds of radiation seems to explain this, the more penetrating X-rays producing a phosphorescence which is more intense and of longer duration than that following the less penetrating light-rays. [See Abs. 858 (1912).]
E. H. B.

1050. *Characteristics of Alkali-Earth Selenide Phosphores.* **F. Kittelman.** (Ann. d. Physik, 46. 2. pp. 177–196, Jan. 28, 1915.)—A lengthy paper dealing with phosphores of the type R_1SeR_2, where R_1 is one of the alkaline-earth metals (Ca, Sr, and Ba) and R_2 is a heavy metal. The phosphores are prepared, after the manner of Lenard and Klatt, by fusing the alkaline-earth carbonates or oxides with pure selenium in the proportion of 3 or 2 to one.

The amount of heavy metal (Cu, Mn, Bi, Pb, Ag, Zn, Ni, Sb) to be added, to obtain the best results, is determined by experiment and differs widely in individual cases, in several being relatively great. If unit weight of selenide is regarded, the order of the weight of the added heavy metal varied between 10^{-6} and 10^{-8}. In some cases amounts of $Na_2B_4O_7$, Li_3PO_4, CaF_2 or KCl were added and the order of the weight of these was about 10^{-3}. Observations of the phosphorescence were made ocularly and spectrophotographically whilst excitation was carried out with a quartz-mercury lamp and a carbon arc.

Pauli has already prepared 6 seleno-phosphores, and now 10 new well-defined cases have been added. Unlike the analogous sulphur phosphores, seleno-phosphores possess, with two exceptions, only one phosphorescent band. In general the maxima of these bands lie in the red end of the spectrum—never in the blue, seldom in the blue-green, and most often in the yellow-green and orange. Curve diagrams are given showing the regions of the phosphorescent band maxima and the corresponding maximal regions of excitation for the individual phosphores. Stokes' rule is rigidly obeyed throughout. Intensity and duration of phosphorescence go hand in hand, and neither attains such values as are characteristic of the sulphur phosphores. If the phosphorescence persisted for a minute it was regarded as being very large. The addition of such widely different chemical compounds as the substances already mentioned appeared to be without much influence on the character of the phosphorescence. Compared with the analogous sulphur bodies the regions of phosphorescence and excitation are both shifted towards the red, and in some cases excitation even was wholly confined to the visible regions. The phosphorescent maxima and the corresponding excitation maxima were found to exhibit no definite kind of regularity. The effect of temperature as a variant, over a wide range (—180° to 200°) has also been investigated. Chief amongst several important deductions is that this variant in the case of the seleno-phosphores alters the intensity and duration, but not the spectrum position, of the phosphorescence. A few exceptions were found to the rule of Lenard and Klatt, that for any given heavy metal in the three alkaline-earth phosphores the emission maximum moves towards the red with increasing atomic weight of the alkaline-earth metal.

The author discusses his results in the light of Lenard's views, for which, he claims, they furnish strong support. C. S. G.

1051. *Method of Calculating Absorption Coefficients of Different Substances for Homogeneous X-radiation.* **H. Moore.** (Phys. Soc., Proc. 27. pp. 432–438; Disc., 438–439, June, 1915.)—The action of X-radiation when passing through a gas is to liberate electrons from the gas. The number of electrons emitted by any atom in a beam of X-rays is proportional to the fourth power of its atomic weight (or possibly its atomic number) [Abs. 697 (1915)]. Thus equal numbers of atoms of different elements, when subjected to similar X-ray beams, will liberate amounts of electronic radiation proportional to the fourth powers of the atomic weights of the elements.

The absorption coefficients are proportional to the amounts of electronic radiation liberated, and therefore the absorptions of two elements, when equal numbers of atoms are present, will be proportional to the fourth powers of their atomic weights.

The corpuscular radiation liberated in the vapour of an element, if it could be obtained as a monatomic vapour at 76 cm., can be expressed as $1{\cdot}05 \times 10^{6} \times (\text{atomic weight})^4$, taking the corpuscular radiation in air as unity. The absorption coefficient of such a vapour would, therefore, be this number of times the coefficient of absorption of air for the same type of X-radiation. The absorption of any element is proportional to the number of atoms present, and having calculated the absorption in a hypothetical vapour of this type, the absorption in the same element in any condition can be calculated by a simple density law.

This is done for several elements (metals), and also, assuming an additive law, it has been calculated for some compounds. The agreement between the calculated values and the values obtained by different observers by direct experiment is quite close over a considerable range of radiations and absorbers. When, however, the atomic weight of the absorber is higher than that of the radiator, so that the K series is absent from any secondary radiation excited in the absorber, the agreement ceases. A possible explanation of this is suggested. AUTHOR.

1052. *Relation between Absorption and Wave-length of X-rays.* **M. Siegbahn.** (Phys. Zeitschr. 15. pp. 753–756, Aug. 15, 1914.)—In the measurements of Moseley and Darwin and of Moseley [Abs. 1833 (1913), 1249 (1914)] a large range of wave-lengths of the characteristic radiations for different elements is available. Again, the absorption μ/ρ of these radiations in Al has been measured in many cases. The author tabulates these two sets of data and plots a curve connecting $\log (\mu/\rho)_{Al}$ and $\log \lambda$, and shows that this curve is a straight line represented by the equation—

$$\log (\mu/\rho)_{Al} = \beta + x \log \lambda,$$

where β and x are constants.

From analogous determinations of the absorption of characteristic radiations in various other elements it is shown that this relation holds with great accuracy for wave-lengths greater than that of a homogeneous radiation. Using Barkla's values for (μ/ρ) of different characteristic radiations in a large range of elements a series of curves are plotted to illustrate this point. Hence it is shown that the above relation holds good for other metals and gases outside the range of selective absorption; the value of the constant x being the same in all cases (approx. = 3). Using the formula given above the author deduces the well-known relations of Barkla and Sadler, and of Owen, connecting the quantities (μ/ρ) and atomic weight. A. B. W.

1053. *Intensity and Absorption Coefficient of X-rays from Platinum and Carbon.* **H. Kirschbaum.** (Ann. d. Physik, 46. 1. pp. 85–129, Dec. 29, 1914.)—The earliest workers with X-rays showed that the intensity and penetrating power of these rays were essentially dependent on the electrode p.d. employed. Röntgen examined the question, using a Pt antikathode, by employing the photographic and fluorescence methods of detection and comparison. Since that time various workers have touched upon this subject; but little systematic research has been carried out. It was with this object in view that the work described in the present paper was undertaken. A series of measurements of intensities and absorption-coefficients have been made, using different substances as antikathode and employing a wide range of electrode p.d.'s which could be accurately measured. The paper commences with a detailed description of the electrometer and spark-micrometer used in the experiments which follow. By means of a ground glass stopper the antikathode of the X-ray bulb could easily and quickly be removed and exchanged, the tube being re-evacuated by means of a Gaede pump; antikathodes of Pt and carbon were used throughout the experiments. After describing the photographic and ionisation methods of examining the X-radiation emitted from the bulb, tables and diagrams are given showing the results of a large number of experiments. The author arrives at the following conclusions:—(1) For the same electrode p.d., the X-radiation from a Pt antikathode is approximately 17 times as intense as that from a carbon antikathode. (2) Both Pt- and carbon-radiation is emitted unsymmetrically with regard to the plane perpendicular to the direction of the incident kathode-stream. The intensity ratio $I_{80^\circ}/I_{120^\circ}$, with 12,000 to 50,000 volts p.d., for a carbon antikathode, lies between 1·50 and 1·90; and for a Pt antikathode, between 1·07 and 1·28. (3) The *electrical* coefficient of absorption of X-rays is, in general, different from the *photographic* coefficient of absorption. (4) The absorption coefficient in Al of the carbon-radiation is, for all electrode p.d.'s investigated, greater than that for Pt-radiation, approximately in the ratio 1 : 0·77. (5) The absorption coefficient varies, in the range 12,000 to 25,000 volts, with the electrode p.d.; with increasing p.d. the coefficient decreases very slowly. (6) For electrode p.d.'s less than 25,000 volts the absorption coefficient varies only very slightly with the azimuth. Thus for carbon-radiation $k_{80^\circ}/k_{120^\circ}$ is equal to 0·955. (7) For an electrode p.d. of 28,000 volts the azimuth of max. intensity is less than 66°. A. B. W.

1054. *X-rays and the Structure of the Diamond Crystal.* **E. Keller.** (Ann. d. Physik, 46. 1. pp. 157–175, Dec. 29, 1914.)—A long theoretical discussion of the crystallography of the diamond. In the course of other work the author has had occasion to look through the data, obtained by Laue, W. Friedrich, Bragg, and others, in connection with this subject, and here he summarises critically the determination of the Laue indices, the Bragg lattice structure and its confirmation by the X-ray spectrum, and a number of other points concerning the structure of the crystal for which reference must be made to the original paper. D. O. W.

1055. *Spectrum of Homogeneous Secondary X-rays.* **M. Glagolev.** (Comptes Rendus, 160. pp. 709–710, May 13, 1915.)—A preliminary account of an investigation of the reflection of secondary X-rays by crystalline surfaces. Secondary rays from a copper plate were reflected by a crystal of NaCl on to a photographic plate. After an exposure of 12 hours two lines, one strong and one faint, were obtained on the plate; but no trace of a continuous spectrum. The wave-lengths were calculated and within the limits of experimental accuracy (6 %) agree with those obtained by Moseley for the α and β copper lines. D. O. W.

1056. *Question on a Law of Emission of Homogeneous X-rays.* **J. Laub.** (Deutsch. Phys. Gesell., Verh. 17. 6. pp. 104–108, March 30, 1915.)—It has been shown by Kossel that the mass absorption coefficient of the elements Fe, Ni, Cu, Zn for their K-radiation is expressed approximately by the formula $(a/D)_K = 4{\cdot}46 \times 10^4/N^2$, where N indicates the place of the absorbing element in the periodic system. The same author has also shown that Al and Ag do not conform with this law. In the present paper Laub extends the investigation to a wider range of elements and to other kinds of radiation (including the L-type). It is shown in the tables given that Barkla's specific absorption coefficient is approximately expressed by the equation—

$$(\lambda/\rho)_{Al} = K/N^{6\cdot5},$$

where the mean value of $K = 1663{\cdot}5 \times 10^8$. The maximum deviation from this mean value of K is 15·8 %. As this deviation is rather large the author suggests a slight modification of the above formula. Thus, dividing the elements into groups:—

Group of Elements.	Characteristic Equation.	Value of Constant K.
I. Fe, Cu, Ni, Zn, As, Se	$(\lambda/\rho)_{Al} = K_1/N^6$	$K_1 = 2836{\cdot}8 \times 10^7$
II. Br, Rb, Sr, Mo, Rh, Ag, Sn ...	$(\lambda/\rho)_{Al} = K_2/N^{6{\cdot}5}$	$K_2 = 1768 \times 10^8$
III. Sb, J, Ba, Ce	$(\lambda/\rho)_{Al} = K_3/N^7$	$K_3 = 1164 \times 10^9$

With these modifications the largest variations observed are below 6 %. It is shown that the softer the characteristic radiations of the group, the larger are the values of the constants K. The ratio of the constants for the two chief classes of the same group of elements is of the order 10^2. Similar relations are shown to hold in the case of the L-type of X-radiation. Further observations are necessary before all elements and all kinds of radiations can be discussed in this way. A. B. W.

1057. *Quantum-effect in High-frequency Spectra.* **A. Landé.** (Phys. Zeitschr. 15. pp. 793–794, Sept. 15, 1914.)—Franck and Hertz [Abs. 1583, 1584 (1914)] have shown that the Hg-atom, if bombarded by electrons, would be ionised and would emit the ultra-violet resonance line $\lambda = 253{\cdot}6\,\mu\mu$ if the kinetic energy of the incident electrons reached the critical value $\epsilon_c = hc/\lambda = h\nu$. It is to be expected that a similar relation holds for other elements and for other characteristic spectrum lines. Using Moseley's relation connecting atomic numbers, N, with the frequencies, ν, of Barkla's K and L series, and Whiddington's determinations of the critical energies ϵ_c the author constructs the following table:—

Element.	Whiddington.		Moseley.		Quotient $\epsilon_c : h\nu$.
	Observed Volts.	Calculated $\epsilon_c : e$.	Observed $\lambda \times 10^8$.	Calculated $h\nu : e$.	
Al...........	2200	7·3	8·346	5·0	1·4
Cr	7820	24·4	2·301	18·1	1·3
Fe	9600	32·0	1·946	21·6	1·4
Ni	10,750	35·8	1·662	25·2	1·4
Cu	11,080	36·9	1·549	27·0	1·3
Zn	11,280	37·6	1·442	29·0	1·3
Se	15,400	51·3	—	35·0	1·4

It is shown from these considerations that in the range of X-ray frequencies of all elements so far examined, there exists a quantum-effect exactly analogous to that observed by Franck and Hertz in the ultra-violet. A. B. W.

1058. *X-ray Spectrum of Platinum.* **H. Seemann.** (Phys. Zeitschr. 15. pp. 794–797, Sept. 15, 1914.)—In this communication the author describes in detail an arrangement by which extremely sharp lines on the X-ray spectrum of Pt can be obtained; a reproduction of one of the photographs obtained by this arrangement is given. It is shown that the broad continuous bands observed by other authors in the X-ray spectra of Pt consist actually of a large number of very narrow lines closely packed together. In the same way, several lines which have up to now been considered simple are shown to be complex. **E. Wagner.** (Ibid. 16. pp. 30–32, Feb. 1, 1915.)—Seemann's experiments have shown this spectrum to consist of a large number of lines closely packed together, whereas previous observers had found it to be a continuous band. Seemann considers that by using a stationary crystal (instead of Broglie's method of rotating the crystal) and employing a very narrow slit, a much higher resolving power is attained. Since this result is of great importance in X-ray spectroscopy, Wagner attempts to prove experimentally that the lines obtained by the stationary-crystal method are possibly, though not essentially, a consequence of the well-known faulty structure of rock-salt crystals, and that the faults of structure can be made almost imperceptible by the revolving-crystal method. Using both methods and high resolution with very narrow slits, the essentially fine-line structure of the X-ray spectrum of Pt is demonstrated. It is shown that the usual faults of an ordinary rock-salt crystal are reproduced to some extent in the X-ray photograph obtained by the stationary-crystal method; by rotating the crystal, however, this effect is so uniformly distributed over the photograph that even large distortion of the crystal (under suitable photographic conditions) becomes almost unnoticed in the photographs, and is only made evident by a slight blurring of the brightest lines. **H. Seemann.** (Ibid. 16. pp. 32–33, Feb. 1, 1915.)—Referring to the results obtained by Wagner with regard to faulty structure of rock-salt crystals Seemann states that the crystals used in his own experiments were "polished like glass and were without visible flaws or curvature"—hence his X-ray photographs by the stationary-crystal method were unspoilt by the presence of faults such as those indicated by Wagner. A. B. W.

1059. *Radio-active Recoil.* **L. Wertenstein.** (Annales de Physique [ix], 1. pp. 347–392, April, and pp. 393–432, May, 1914.)—When RaA emits an α-particle, the residual atom (now RaB) is itself projected and recoils, and this recoil of RaB is called the *a*-ray change of RaA. The *a*-rays are many times slower than the α-rays; if β-ray changes could be studied in a similar way, the movements predicted by the kinetic theory of the gases might be observed. The RaB itself gives off β-rays, but not so rapidly; this complicates the observations, which are difficult to follow because the *a*-ray has small penetrating power owing to its big mass and its slow velocity. The author allows the projected residual atom (which may itself be radio-active) to be deposited on another body which he calls the receptor. A preliminary study of the range of the *a*-radiations of RaA in air, in hydrogen (both at atmospheric pressure), and in a film of silver on glass gave the values 0·12, 0·72, 0·00002 mm. (or 20 $\mu\mu$ in the last case); more exact determinations with canalised rays yielded the ranges 0·14 and 0·83 mm. (air and hydrogen). The ranges of the *a*-radiation are thus about 1/350 of the ranges of the α-radiation, whilst the kinetic energy of an *a*-particle is 1/50 of that of the α-particle, so that the *a*-particle loses much more energy in its course than the α-particle. For about the first half of the path in air (less than half in hydrogen) the number of *a*-particles remains constant; afterwards it decreases at an increasing rate owing to the scattering caused by the collisions with the molecules of the medium. The numbers of *a*-particles and of α-particles emitted from plane surfaces are practically equal. The ionisation caused by the *a*-particles is much greater than that due to α-particles; but *a*-particles lose much more energy (as stated) probably because they impart some of their energy, in the form of kinetic energy, to the molecules with which they collide, and the ionising power of the *a*-particles decreases as their speed diminishes, whilst the ionising power of *a*-particles becomes greater at the extreme end of their range where their speed is diminished. The collisions of the *a*-particles seem to be intermediate in character between the ordinary collisions of gas molecules and those of *a*-particles at the commencement of their paths. H. B.

1060. *Photographic Action of a-, β- and γ-Rays.* **R. R. Sahni.** (Phil. Mag. 29. pp. 836–841, June, 1915.)—In the course of an investigation on a photographic method of dealing with the scattering of *a*-particles, the author has found that the Wratten and Wainwright lantern-plate is the most suitable, as it presents the cleanest surface when examined microscopically after development. The most suitable developer for use with these plates is also given. Using *a*-ray sources, photographs similar to those of Kinoshita and Ikeuti [Abs. 569 (1915)] have been obtained, showing clearly the radial character of the tracks of the *a*-particles. Using Th active deposit and RaE as sources of β-rays, the distinction between the effect of *a*-rays and β-rays is clearly brought out. The distinct radial character of the *a*-photographs is altogether absent on the β-photographs: in the latter case no straight tracks are visible. In the case of β-photographs also there is no well-defined centre, the dark nucleus, when formed, being irregular and nebulous. As would be expected, the γ-ray photographs were found to be similar to the β-ray photographs of the same magnification—illustrating the production of secondary β-rays by γ-rays. A. B. W.

1061. *Magnetic Spectrum of the β-Radiation from Radiothorium and Thorium-X.* **O. v. Baeyer, O. Hahn** and **L. Meitner.** (Phys. Zeitschr. 16. pp. 6–7, Jan. 1, 1915.)—A continuation of previous work [Abs. 1194 (1912)]. The same method of investigation was employed, and it was found that radiothorium emits β-rays with velocities 0·47 and 0·51 of the velocity of light. Both these values are characteristic of the β-radiation from ThX. This result is briefly discussed. A. W.

1062. *Gamma-ray Method of estimating Radium in feebly Radio-active Substances.* **W. Bothe.** (Phys. Zeitschr. 16. pp. 33–36, Feb. 1, 1915. Communication from the Physikal.-Techn. Reichsanstalt.)—The determination of the Ra-content of feebly radio-active substances (soils, etc.) has generally been made by the emanation method. This method takes a considerable time and requires rather elaborate apparatus, whereas the γ-ray method is much quicker and less expensive initially. On the other hand, the γ-ray method has the disadvantage that any mesothorium in the substance will be estimated as radium, whereas in the emanation-method the *true* Ra-content is measured. The author describes the detailed construction and method of use of an electroscope by means of which it is easily possible to measure extremely small quantities of radium in mesothorium-free substances. After discussing the essential features of such an electroscope a description of one actually in use is given.

Measurements are made on the absorption of γ-rays observed when different substances (lead chromate, calcium oxide, sand, etc.) are mixed in varying proportions with known quantities of the radio-active substance. The results of a series of observations of this character are tabulated, the experimental values being in good agreement with those obtained by calculation. A. B. W.

HEAT.

1063. *Thermal Capacity of Metals and Metallic Compounds,* 18° *to* 600° C. **P. Schübel.** (Zeitschr. Anorg. Chem. 87. pp. 81–119, 1914.)—The 15 metals and 18 intermetallic compounds investigated are those studied by Schimpff, except that the author does not examine gold and silicon. The specimen is heated up to a certain temperature in a vertical electric furnace and dropped into a water calorimeter (copper vessel, walls 0·1 mm. thick). Observations are taken at 18°, 100°, 200°, 300°, 400°, 500°, 600° C., and from the mean specific heats the true specific heats are deduced by graphical methods; comparison with other observations are also made. On the whole the observations of different investigators are in good agreement; the discrepancies become more pronounced at higher temperatures. According to Neumann-Kopp the molecular heat of a compound should be equal to the sum of the atomic heats; this is confirmed within 2% for most of the compounds and within 5% for all of them; Mg gives generally too low, Sb too high values in compounds, but Cu_2Mg yielded too high a value at 500°; Cu_2Sb and Cu_3Sb gave too high, Ni_3Sn and Ni_2Mg too low values. The curves of true atomic heat of both the metals and the compounds are strongly curved between —100 and 0°, and become nearly straight above 100°, except for Ag, Sb, Cr, Ni. The calculations of the atomic heats, c_v, at constant volume approach the limit 5·97 of Nernst in the case of Al, Mg, Cu, Ag, Sb, Zn, and also of Pb and Mg; in the case of Fe, Ni, Co, Cr, Bi, Sn the limit is decidedly exceeded. In the case of intermetallic compounds the values of $c_p - c_v$ cannot be determined, the coefficients of expansion and of compressibility being unknown. H. B.

1064. *Measurements of the Specific Heats of Liquids.* **A. Heydweiller.** (Ann. d. Physik, 46. 2. pp. 253–260, Jan. 28, 1915.)—An account of a method of comparing the specific heats of two liquids, by electrical heating, which has been used by the author for several years for comparing the specific heats of solution and solvent. Two nearly identical calorimeters are employed, as in the Pfaundler method, each containing a single coil of Pt-wire which is made to serve both as a resistance thermometer and as a heating coil. The electrical connections are arranged so that these coils can be either in series with the cells which supply the heating current or put in the adjacent arms of a Wheatstone bridge. To make the external heat-loss as small as possible each calorimeter consists of two Dewar vessels one inside the other, the outer being silvered and the inner having a nett capacity of about 20 cm.^{3}, so that only very small quantities of liquid are required. An experiment is first made with equal masses of the liquid of known specific heat in each calorimeter; one of them is then emptied, a suitable quantity of the second liquid is put in, and the experiment repeated. The paper contains a detailed account of the apparatus and a numerical example to show the exact method of deducing the result. D. O. W.

1065. *Gas Equilibrium and Specific Heat by the Explosion Method.* **W. Siegel.** (Zeitschr. Phys. Chem. 87. pp. 641–688, 1914.)—The experiments are a continuation of the work of M. Pier, N. Bjerrum, and H. Budde, and are made by the same method in order further to investigate the loss of heat observed in the explosions of electrolytic gas in the interval between the moments of ignition and of max. temperature. When there is an excess of hydrogen, the loss of heat cannot quantitatively be calculated, but it can be neglected when the initial pressure is raised to 2 atmos., which is quite feasible in the bombs. The curves of the specific heat and of the dissociation of water-vapour do not show the anomalous rise of Bjerrum; Pier's formula for the change of the specific heat with temperature is confirmed for the range 2200° to 2900° abs. The experiments with an excess of oxygen would not lend themselves to calculations, apparently owing to the presence of some unknown compound (? H_2O_4). The experiments do not suggest any dissociation of hydrogen and of oxygen themselves; if any such dissociation should take place (Langmuir), the lower limit of the heat of dissociation should be about 150,000 cals. in the case of hydrogen, and 160,000 cals. in the case of oxygen; both these figures would be higher than Langmuir's estimates. H. B.

1066. *Mechanical Equivalent of Heat.* **R. Freund.** (Phys. Zeitschr. 15. pp. 817–824, Oct. 1, 1914.)—~~L.~~ Weber has described a method of determining "J" by observing the heating produced in a metal cylinder placed in a rotating magnetic field. Lampa afterwards worked with this method, the rotating field being generated by the stator of an induction motor. The author has used a modification suggested by Tuma. A copper cylinder, suspended by a bifilar, is placed symmetrically between the poles of an electromagnet which can be rotated about the cylinder's axis by means of a motor. The angular displacement of the cylinder is balanced by the bifilar couple. The work done in N revs. = Moment of bifilar couple × 2πN. The mass of the cylinder and the rise of temperature being known, "J" can be calculated. The temperature was measured by thermo-couples. The angular displacement was varied between 8° and 26°. The mean value of "J," 426·2, was deduced from the following 8 values: 427, 429, 426, 424, 426, 427, 425, and 426. I. W.

1067. *Exponential Scale of Temperature.* **R. H. Weber.** (Phys. Zeitschr. 16. p. 9, Jan 1, 1915.)—Discusses some properties of the exponential scale recently referred to by T. Peczalski and advocated for two years past by the present author.

If the ordinary absolute temperature is T and the new exponential temperature τ then the relation is $T = T_0 e^{\alpha(\tau - \tau_0)}$.

Between T and τ the following numerical relations hold:—

T.	τ.
0°	$-\infty$°
273°	0°
(273 + 100)°	100°
(273 + 500)°	371·54°

E. H. B.

1068. *Estimation of High Temperature by Colour Identity.* **C. C. Paterson and B. P. Dudding.** (Phil. Mag. 29. pp. 34–63, July, 1915.) [See Abs. 706 (1915).]

1069. *Dependence on the Temperature of certain Physical Properties of Water in its Various States of Aggregation.* **I. W. Cederberg.** (Phys. Zeitschr. 15. pp. 824–831, Oct. 1, 1914.)—It has been shown [Abs. 1694 (1914)] that the magnitude a of van der Waals' vapour-pressure formula, $\log (\pi_0/p)=a(\vartheta_0/T-1)$, where π_0 and ϑ_0 are the critical pressure and temperature, p the vapour-pressure, and T the absolute temperature, as a function of the temperature may be represented quite generally as a simple exponential expression. Further applications of these relations are now developed theoretically. From the Clausius-Clapeyron equation, $dp/dT=\lambda/T(V-v)$, the formula, $\log p=-M\lambda_0/RT+1{\cdot}75 \log T-M\epsilon T/R+C$ is deduced, λ_0 being the molecular heat of evaporation at absolute zero, ϵ an empirical constant, c Nernst's "chemical constant," and M the modulus of Briggs's logarithms. The value of c is calculated for about 20 different compounds and it is found that for nearly all of these, $C=\log \pi_0+1{\cdot}2$; the only two exceptions found to this rule are helium and hydrogen, for which c exceeds $\log \pi_0$ by 0·2 and 0·5 respectively. It was shown previously (*loc. cit.*) that the equation, $\log (\pi_0/p)=\alpha\,.\,\beta^{(T/\vartheta_0-\gamma)^n}.\,(\vartheta_0/T-1)$, expresses well the vapour pressure of water over the whole extent of the liquid phase, and a table is given showing the calculated and observed values of p for a number of temperatures. That this formula lends itself to extrapolation is shown by the agreement between the values calculated from it and those deduced in another way by Nernst for very low temperatures. On the assumption that the vapour-pressure curve for the solid phase, when prolonged beyond the melting-point cuts the curve for the liquid phase at the critical point, it is shown that the above formula gives values for the vapour pressure of ice in excellent agreement with those observed experimentally down to very low temperatures. Further, in conjunction with the Clausius-Clapeyron equation, this formula gives accurate values for the heats of vaporisation of water and sublimation of ice. The difference between the molecular heat of saturated water-vapour under constant pressure and that of liquid water (C_p-c), is affected only very slightly by the temperature, its mean value for the temperature-interval, 0–50°, being $-9{\cdot}806$, whilst at 0° the value is 9·8. On the assumption that the molecular heat of liquid water at 0° is 18, C_p will be 8·2, this number agreeing well with that required by the kinetic theory of gases, namely, $4R=7{\cdot}94$. This method of calculation gives only the difference between the molecular heats of saturated vapour and condensate, and affords no indication of the temperature variations of the separate molecular heats. T. H. P.

1070. *Experimental determination of the Critical Constants of Oxygen, Nitrogen, Carbon-monoxide, and Methane.* **E. Cardoso.** (Archives des Sciences, 39. pp. 400–402, May, 1915.)—In continuation of previous determinations [Abs. 278 (1914)], the author has determined the critical constants of the above gases. The results obtained are as follows :—

	Critical Pressure in Atmospheres.	Critical Temperature (Centigrade).
Nitrogen	33·65	— 144·7°
Carbon monoxide	34·60	— 138·7°
Oxygen	49·30	— 118·0°
Methane	45·60	— 82·85°

A. F.

1071. *The Vapour Pressure of Iodine between* 50° *and* 95°. **G. P. Baxter and M. R. Grose.** (Am. Chem. Soc., J. 37. pp. 1061–1072, May, 1915.)—Previous work [Abs. 1725 (1907)] has been extended. The vapour pressure of solid iodine is found to have the following values :—

Temperature.	Vapour Pressure. mm.	Temperature.	Vapour Pressure. mm.
50°	2·154	75°	11·21
55°	3·069	80°	15·09
60°	4·285	85°	20·21
65°	5·962	90°	26·78
70°	8·196	95°	35·24

From these and the previous determinations, we find the following alternative equations for the vapour pressure of iodine from 0° to 95°—

$$\log p = -106{\cdot}3930 + 46{\cdot}611 \log T - 0{\cdot}031677T \,; \log p = 9{\cdot}7522 - 2863{\cdot}54/(T-19).$$

The average molecular heat of sublimation of iodine at these temperatures is calculated to be 14·7 kg. cals. or 61·6 kilo-joules. A. F.

1072. *Calculation of the Despretz-Trouton Constant.* **D. Berthelot.** (Comptes Rendus, 160. pp. 657–660, May 17, 1915.)—The constant referred to is obtained when the quotient is taken of the molecular heat of vaporisation by the absolute temperature of the boiling-point at atmospheric pressure, a number in the vicinity of 20. The constant becomes 18 if the internal heat of vaporisation be taken, since 2 has to be subtracted for the external work of the former relation. This constant is found to hold for a large number of cases and particularly for non-polymerised organic liquids, and although discovered empirically it was later deduced theoretically from the principle of corresponding states. An exact knowledge of the characteristic equation for liquids would admit of the constant being evaluated, but satisfactory agreement between the experimental and calculated values has not up to now been attained. The author here attempts to reconcile experiment and theory. Taking Van der Waals' equation, the quotient L/T becomes $9/2(2/\theta-1)$, where L is the internal latent heat, T the absolute temperature of boiling-point, and $\theta = T/T_c$, T_c being the critical temperature. Now $\theta = 2/3$ so that $L/T=9$, *i.e.* only half the experimental value. The discrepancy being due to the characteristic equation, the author now refers to a modified characteristic gas equation proposed by him [see *Travaux du Bureau international des Poids et Mesures*, pp. 1–113, 1902], and available between extensive temperature limits, from which L/T becomes $6/\theta(2/\theta-1)$, and gives a value 18 when $\theta = 2/3$. The author claims this result in support of the general applicability of his gas equation. H. H. Ho.

1073. *Fluctuation of Energy in Gases.* **K. Széll.** (Deutsch. Phys. Gesell., Verh. 17. 7. pp. 122–130, April 15, 1915.)—A mathematical theory in two parts based on Boltzmann's principle and the kinetic gas theory respectively.
E. H. B.

1074. *Diffusion Coefficient of Gases and Viscosity of Gas Mixtures.* **J. P. Kuenen.** (K. Akad. Amsterdam, Proc. 17. pp. 1068–1072, Feb. 27, 1915.)

—Miss A. Snethlage recently drew the author's attention to the fact that the expression given by him for the persistence coefficient could not be correct. A recalculation led to the discovery of the error, and the correct value is here given, together with the consequent corrections required of results obtained in previous communications [Abs. 1432 (1914)]. G. W. DE T.

1075. *Relation between the Joule-Thomson Effect, the Specific Heat, and the Equation of State.* **R. Plank.** (Phys. Zeitschr. 15. pp. 904–914, Dec. 1, 1914.)—A mathematical treatment which issues in the establishment of a relation between any T′ and the pressure P′ at which the pressure influence on the cooling effect changes sign. This relation is written—

$$P' = \frac{C_2RT'(T'/273)^n - nC_1^2}{\frac{3}{2}C_1C_2n}.$$

E. H. B.

1076. *Mechanism of Molecular Action.* **T. C. Sutton.** (Phil. Mag. 28. pp. 798–808, Dec., 1914.)—The author points out that many problems can be attacked, alternatively, from the point of view of thermodynamic theory or of the kinetic theory of gases. The former has been far the more fruitful, simply because the mechanisms of ultimate molecular action, on which the further development of the kinetic theory must be based, are as yet unknown. His object here is to find possible mechanisms in agreement with thermodynamic theory. Starting with the consideration of the conditions of max. entropy of a gaseous mixture by the methods of Gibbs and Planck, a relation is obtained expressing the velocity of any gaseous reaction, chemical or otherwise, in terms of temperature and other conditioning circumstances. Two alternative mechanisms are found which satisfy this relation, but no mathematical guarantee is obtained excluding the existence of other possibilities. It is then shown that the various molecules of a pure substance, although of identical atomic composition, differ in the configuration and motion of these constituent atoms, according to a definite law which is mathematically formulated. The analysis applies directly only to gases and dilute solutions; but the mechanisms derived demand only conditions which may be satisfied in the liquid and solid state generally, and it is difficult to conceive the mechanism applying in one case and not in others. It would appear, therefore, that the law is a general one, though rigidly demonstrated only for gases and dilute solutions. G. W. DE T.

1077. *Partition of Energy and Newtonian Mechanics.* **G. H. Livens.** (Phil. Mag. 29. pp. 383–394, March, 1915.)—Various attempts have been made to prove that the only possible law of steady thermal radiation, according to ordinary Newtonian mechanical principles, is that which corresponds to equipartition of energy among the various oscillations, a conclusion which is, however, totally in disagreement with experimental results. The author points out that, although the equipartition law apparently provides the right formula for long-wave radiation, its application even here is open to serious objection. For the presumable continuity of the spectrum of pure thermal radiation would compel us to assume that the total number of wave-lengths, even in a small range $d\lambda$ of the spectrum, is infinite. There would therefore be an infinite number of oscillations securing on the average the same finite amount of energy on the equipartition law, so that an infinite amount of energy would be associated with the small range $d\lambda$ in any part of the spectrum. The author suggests that what require revision are the principles of the calculus of probabilities as applied to such problems, rather than the principles of Newtonian dynamics, and he shows that a form of the theory in agreement with experiment is attainable without any incongruity with Newtonian mechanics, merely by abandoning the assumption that all dynamical co-ordinates which enter into the expression for the energy of any system are necessarily equally probable as receptacles of energy. This suggested modification applies most particularly to those co-ordinates, infinite in number, introduced by the use of Fourier's series and usually expressed by the coefficients in these series. He shows, moreover, that if there is any reason to suppose that the various co-ordinates, and in particular the co-ordinates of the Fourier series, are to be differentiated from one another as here suggested, then equipartition of energy is hardly to be expected. And any such differentiation in type, although not actually contained in our usual stock of dynamical ideas, is at least as consistent with those ideas as the usual assumption, so that there is every reason for adopting it as a useful, if arbitrary, additional hypothesis to replace the one already in use. The author observes that his main contention is capable of explanation in terms of a well-known difficulty in the ordinary statistical kinetic theories connected with the "continuity of the path" of a dynamical system. It is, in fact, definitely denied that a dynamical system which involves in its essential constitution a perfectly irregular mass of vibrating elastic matter, or ether, when started from any phase will traverse every other phase geometrically consistent with the energy condition. In fact, motions of the system in which more than a limited finite number of the higher vibration co-ordinates possess an amount of energy comparable with that of a dynamical coordinate of ordinary type, *e.g.* the translation of a gas molecule, are both mathematically and physically impossible. G. W. de T.

1078. *The Gas Equation at Low Temperatures.* **O. Sackur.** (Deut. Chem. Gesell., Ber. 47. pp. 1818–1828, 1914.)—The author attempts to apply the quantum theory not only to oscillation phenomena (radiation, specific heat of solids), but also to the translational velocity of gas molecules, and finds that the so-called chemical constant of simple gases can be calculated from the molecular weight and Planck's universal constant h, implying that the kinetic energy of a substance still retains a definite value at absolute zero. He further concludes that the pressure of ideal gases does not follow the law of Boyle-Gay Lussac at low temperatures, but is always greater than RT/V, being the greater, the lower the temperature and the greater the density of the gas. Only with infinite dilution is the $PV = RT$ law fulfilled at all temperatures. In accordance with his experiments he modifies the gas equation in such a way that the curve of the relation between pressure and PV becomes concave with regard to the pressure abscissa. The concavity is quite marked for hydrogen (at —253°), less distinct in the case of helium, and not noticeable in the case of nitrogen and oxygen. H. B.

1079. *Constant of Total Radiation of a Black Body.* **W. W. Coblentz.** (Phys. Zeitschr. 15. pp. 762–764, Aug. 15, 1914.)—In a previous paper [Abs. 901 (1914)] the author has given data with reference to the radiation constants of a uniformly heated enclosure. A number of experiments were undertaken to determine the constant of total radiation (σ) for a black body. The radiator employed was an electrically heated porcelain tube after Lummer and Kurlbaum; and this was blackened, in the manner previously described, with a mixture of cobalt oxide and chromium oxide. The results obtained for the constant of total radiation fall into two groups. The mean value for the group of lower values is $5{\cdot}6 \times 10^{-12}$ watt cm.$^{-2}$ deg.$^{-4}$. The higher values lie between $5{\cdot}6$ and $6{\cdot}3 \times 10^{-12}$. A. W.

SOUND.

1080. *Pendular Electromagnetic Alternator.* **A. Stefanini.** (N. Cimento, 8. pp. 261–285, Oct., 1914.)—A description of an instrument for producing adjustable high tones of short duration by swinging a pendulum which carries an arc of iron teeth past a magnet pole. Of special service in ear-testing and readily adjusted so as to give the best conditions. A. D.

1081. *On Motion in a Periodic Field of Force.* **C. V. Raman.** (Phil. Mag. 29. pp. 15–27, Jan., 1915.) [See Abs. 1697 (1914).]

1082. *Vibrations of Telephone Membranes.* II. **M. Siegbahn.** (Ann. d. Physik, 46. 2. pp. 298–304, Jan. 28, 1915.)—Describes an improvement of the method of recording these vibrations and illustrates the results by reproductions of more than a score of graphs of the membrane's motions, two being for the vowels *o* and *u* (English $\overline{\text{oo}}$). [See Abs. 291 (1914).] E. H. B.

1083. *Change of Frequency of Vibrating Strings and Bars in Liquids and Gases.* **A. Kalähne.** (Ann. d. Physik, 46. 1. pp. 1–38, Dec. 29, 1914.)—This work is based on two previously published investigations [Abs. 331, 881 (1915)]. The effect of the liquid or gas on the string or bar may be represented by an increase of mass of string or bar, the restoring forces remaining unchanged. This, of course, results in a decrease of frequency. The theoretical and experimental results are in accord. E. H. B.

1084. *Origin of "Wolf-Note" in Bowed Instruments.* **G. W. White.** (Cambridge Phil. Soc., Proc. 18. pp. 85–88, June, 1915.)—On all stringed instruments of the violin type a certain pitch can be found which it is difficult and often impossible to produce by bowing. This note is called the "wolf-note," and usually occurs at an interval of an eleventh or twelfth above the lowest note of the instrument. At this pitch on either string the bow refuses to "bite," and a soft pure tone is almost impossible to obtain; if the pressure of the bow on the string is increased the tone resulting is usually of an unsteady nature with considerable fluctuations in intensity. It was thought that an analysis of the vibration of the belly of the instrument for frequencies in the neighbourhood of the "wolf-note" would settle the question of its origin, as to which there is considerable disagreement among musicians. The instrument selected for test was the 'cello. On such instruments the imperfect note is usually very pronounced, especially when played high up on the G-string.

The vibration of any part of the body of the instrument was recorded as a line on a moving photographic plate by reflecting a beam of light from an optical lever, one leg of which rested on the vibrating surface. Proceeding by steps of a quarter of a tone, it was found that as the wolf-note was approached the vibration curve was much simpler and the amplitude considerably larger. It thus appeared that the pitch of the wolf-note was about that of best resonance of the belly. This view was confirmed by eliciting these belly vibrations in response to the same note blown on a cornet with its bell near the belly of the 'cello. Further, by receiving the trace on a long film on a drum, and bowing the instrument, the fluctuations of intensity were shown to correspond to a waxing and waning of the belly's vibrations or the phenomenon of beats. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1085. *Conduction of Electricity through Metals.* **J. J. Thomson.** (Phil. Mag. 29. pp. 192–202, July, 1915. Paper read before the Physical Soc., June, 1915.)—The discovery by K. Onnes, that at the temperature of liquid helium some metals can exist in a state in which their specific resistance is less than one hundred-thousand millionth part of that at 0° C., appears to necessitate the abandonment of the ordinary theory of metallic conduction, as the experimental conditions prohibit the explanation of the phenomenon by an abnormal increase, either in the number or the mean free path of the free electrons. The effects observed by Onnes may, however, be accounted for by a theory of metallic conduction previously given by the author in his *Corpuscular Theory of Matter*. On this theory the atoms of some substances contain electrical doublets, *i.e.* pairs of equal and opposite electrical charges at a small distance apart. The effect of an applied e.m.f. is to alter the heterogeneous distribution of the axes of these doublets by bringing them into partial alignment with the field. The influences preventing complete alignment are considered, and the theory is worked out mathematically. It is thus shown that it is possible to start with an external field and so produce a polarisation that gives a current; and then gradually reduce the field to zero, but still have a current continuing to flow in the absence of an applied e.m.f., as observed in one of the experiments of K. Onnes. On this view, therefore, the function of the applied field is to produce the alignment of the doublets; the actual transference of electricity is effected by the large inter-atomic forces brought into being by the polarisation of the doublets. Thus, if the polarisation remains on withdrawing the applied e.m.f., the current will also remain. E. H. B.

1086. *The Electron Theory of Metallic Conduction.* **G. H. Livens.** (Phil. Mag. 29. pp. 173–183, Jan., and pp. 425–432, March, 1915.)—After Drude's initial attempts to deduce a formula for the conductivity, the problem appeared to be finally settled, at least as far as its application to the theory of steady currents, by Lorentz's investigations. But his formulæ appear to require modification to make them applicable to rapidly alternating fields, particularly those associated with radiation. The author, by a rigorous argument along the lines laid down by H. A. Wilson and J. J. Thomson [see Abs. 224 (1911), 1545 (1907)] obtains a formula differing from Wilson's by a factor 2/3, which is just what is required to make it consistent with Lorentz's result in the limiting case.

In Part II the author compares the apparently different views of Lorentz on the one hand and Drude, Riecke, Thomson, and Wilson on the other. Both assume a distribution of velocities in accordance with Maxwell's law, in the absence of an electric field. But in the presence of such a field, Lorentz's procedure involves the conclusion that at any instant there are more electrons on the average moving in the direction of the electric force than in the opposite direction. The other method, which appeared to be in contradiction to this, assumes that the whole effect imparted by the electric force on the electron during its free-path motion is obliterated by the collision at the end of the path, so that each free path is started with the velocity the electron would have had throughout it, in the absence of any field of force, the distribution of the initial velocities in the paths thus being specified by Maxwell's law. But the author shows that, starting with the latter assumption, Lorentz's formula may be deduced, so that under these assumptions the average steady distribution of initial velocities is that specified by Maxwell's law. The two modes of formulation of the theory are consequently identical, for it seems clear that the argument may be reversed, or, in other words, that the steady distribution calculated on general grounds by Lorentz necessarily implies that the distribution of initial velocities is that specified by Maxwell's law. The author illustrates this by calculating, by Lorentz's procedure, the average distribution of velocities at any instant when the perfectly irregular motion of the electrons is modified by the application of a simple periodic electric force, and finally arrives at the same result as is obtained by the more direct method suggested by Thomson.

G. W. DE T.

1087. *Motion of the Lorentz Electron.* **G. A. Schott.** (Phil. Mag. 29. pp. 49–62, Jan., 1915.)—The paper consists of some preliminary analytical investigations, undertaken with the view of taking into account the effect on the motion of an electron due to its own radiation. Starting with the vector equation of motion which he has given elsewhere [*Electromagnetic Radiation*, pp. 175, 176, 246], he points out that it must always be used with caution in cases where the velocity of the electron approaches that of light, or in very strong electric or magnetic fields, where the acceleration and curvature of the path of the electron may reach large values. Thus special care is required in applying them to an electron which approaches very closely to the nucleus of Rutherford's model atom, and problems of a similar kind. It is suggested that the frequent apparent failure of the ordinary mechanics and electrodynamics may be due simply to neglect of proper precautions and to an unjustifiable use of admittedly imperfect analytical expressions rather than to defects in the fundamental principles of the electron theory.

The core of an electron moving in a straight line under the action of an electrostatic field in the same direction is investigated, and it is pointed out that an additional arbitrary constant is introduced on the relativity hypothesis for accelerated motions, and a series of arbitrary constants if our mechanics are based on the hypothesis of the extended electron, owing to the fact that the effect of the radiation terms is to give a third-order equation of motion of the electron, when regarded as a differential equation for the co-ordinate. These additional arbitrary elements, in so far as they must be determined by the initial conditions, represent the effect on the motion of the electron of its past history, which in many problems is unknown. The difficulty may be obviated by the additional hypothesis that Newton's laws of motion hold without alteration, so that *when the velocity of the electron is zero its acceleration is equal to the external mechanical force per unit mass.* This hypothesis has the advantage of leading to simple results that can be compared with experimental ones. When the hypothesis is tested by comparison with the experimental determinations of Hupka [Abs. 596 (1910)] it is found that in a field of 20,000 volts/cm., the acceleration of an electron moving with a velocity which is small compared with that of light will not differ from the mechanical force per unit mass by more than one part in the ten-million-millionth power of ten. If there be any such deviation it may vary with the field intensity, but this will probably be inconsiderable, so that Newton's second law of motion may be considered as verified for slowly-moving electrons to a degree of accuracy far beyond that obtained in astronomical investigations. How far the law is applicable to electrons starting from rest in very intense fields, such as those inside or close to the atom, remains doubtful. G. W. DE T.

1088. *Magnetic Field of an Atom.* **H. S. Allen.** (Phil. Mag. 29. pp. 40–49, Jan., 1915.)—The author deduces a formula similar to that of Ritz [Abs. 914 (1908)] from the assumptions that: (1) The core of an atom gives rise not only to an electrostatic field varying inversely as the square of the distance from the centre, but also to a magnetic field such as would be set up by an elementary magnet: (2) The steady states of motion of an electron in the field of the atom are determined by the ordinary laws of electrodynamics, combined with certain specific assumptions as to the angular momentum and the energy of the electron: (3) The energy of the radiation, as in Bohr's theory, is emitted in quanta, which represent the differences between the energies in two steady states of motion. The magnetic forces set up by the atom are, however, found to account only for a small fraction of the effect required to give the observed distribution of lines in spectral series.
G. W. DE T.

1089. *Orbits of a Charged Particle round an Electric and Magnetic Nucleus.* **W. M. Hicks.** (Roy. Soc., Proc. 91. pp. 273–290, April 1, 1915.)—This is a complement to an earlier paper [Abs. 1861 (1914)]. The present more general case of a central charged nucleus possessing mass and a magnetic moment is worked out in detail, the mass of the nucleus being assumed so large compared with that of the revolving particle that it may be regarded as fixed. It is therefore not directly applicable when the revolving body is an α-particle except in cases where the central mass is large compared with that of the H-atom. The modification needed when the motion of the nucleus is not large enough to affect its magnetic quality is determined. The orbits are discussed in detail and illustrated by figures. G. W. DE T.

1090. *Approximately Permanent Electronic Orbits and Origin of Spectral Series.* **G. W. Walker.** (Roy. Soc., Proc. 91. pp. 156–170, Feb. 1, 1915.)—This paper is an attempt to throw light on the question whether the failure to co-ordinate modern experimental work in radiation with the electrodynamic theory of electrons arises from the insufficiency of the approximate simplifications necessitated by mathematical difficulties or from an insufficiently general conception of electronic systems. Calculations taking account of electrostatic forces only may be ruled out from inquiries into the origin of spectra, as Hicks has shown [Abs. 1861 (1914)]. Conway's work on spectral series [Abs. 458 (1914)] appears most promising, but some vital modifications are here shown to be necessary. Promising results are then obtained in accordance with pure electrodynamics. Little regard has yet been paid to consequences of internal rotations of electrons, which, of course, imply a magnetic moment. This must arise, but in varying amount, from the rotation, but, at present, it seems necessary to retain a true permanent magnetic moment. Complete formulation of the equations of motion of two such nuclei should be possible, but very formidable. A simpler problem, to serve as a guide to real cases, is here considered. Corresponding to the atom, assumed to be comparatively massive, a nucleus of radius a is taken, with positive charge E, and permanent magnetic moment μ. It is constrained to be fixed both as regards translation and rotation. The motion of a particle corresponding to a corpuscle with negative charge E is then examined, being assumed to be without permanent magnetic moment, and its internal rotation being neglected. The speed of the particle is assumed small enough to assume an invariable mass m.

The mathematical investigation leads to the following conclusions:— Within a positive nucleus possessing the usual positive charge and possessing a fixed magnetic moment of the value attributed to the magneton, we may have approximately permanent orbits of corpuscles with the usual value of e/m which give rise to series of spectral lines of recognised type. They are probably diffuse and have no structure. Equatorial orbits also give rise to series of the same general character. These are not expressible in so concise a form; the number of lines is limited and may be expected to possess a four-fold structure. The form of equation for the equatorial orbits shows that the Zeeman-effect of the usual type is to be expected. But the orbits of the same angular momentum, although affected by an external magnetic field, do not give structural Zeeman-effect, but an additional general diffuseness only. The radius of nucleus required to give suitable optical values is of the order 10^{-10}, the usual value of the atomic radius being estimated as about 10^{-8}. The wave-length of the rapidly damped disturbance communicated to the exterior is $4\pi a/\sqrt{3}$, rather smaller than the value assigned to characteristic Röntgen radiation. But the wave-length of the radiation from a corpuscle just outside the nucleus comes out about 2×10^{-8}, which is sufficiently near observed values. The value 10^{-8} is derived largely from the kinetic theory of gases for hard spheres, and is admittedly weak. But if substantiated, some explanation would appear possible depending on the range of possible external corpuscular orbits at a given temperature. When the nucleus is free to move corrections will be required. G. W. DE T.

1091. *Brownian Motions and Electric Charges of Metallic Particles, in Gases.* **D. Konstantinowsky.** (Akad. Wiss. Wien, Ber. 123. July, 1914. Ann. d. Physik, 46. 2. pp. 261–297, Jan. 28, 1915. Extracts.)—Using gold and mercury spherules the author claims to have isolated electric charges from 1/50th to 1/200th of the electronic charge. [*Errata*, 46. 5. p. 720, March 15, 1915.] E. H. B.

1092. *Elementary Quantity of Electricity.* **F. Zerner.** (Phys. Zeitschr. 16. pp. 10–13, Jan. 1, 1915.)—Points out that by the work of F. Ehrenhaft the electric charge appears to decrease with the size of the particle. [See Abs. 282 (1911).] E. H. B.

1093. *Singular Parameter Values in the Boundary Problems of the Potential Theory.* **C. E. Weatherburn.** (Roy. Soc. of Victoria, Proc. 27. Part 2. pp. 164–178, March, 1915.)—The treatment is by integral equations. E. H. B.

1094. *Theory of Dielectrics.* **K. Czukor.** (Deutsch. Phys. Gesell., Verh. 17. 5. pp. 73–84, March 15, 1915.)—Starting from the assumption that in crystals, which give a pyroelectric effect, the molecules are asymmetrically bound, the author builds up a theory of pyro-electricity. From a consideration of the similarity of the thermal and electrical polarisation and the application of similar reasoning to the electrons of the dielectric he has deduced a modification of the ordinary Lorentz formula for the dielectric constant, which takes into account the influence of temperature. He shows that in the case of methyl alcohol, ethyl alcohol, and benzol, his formula is in good agreement with the known experimental data. I. W.

1095. *On the Electrification given to the Air by a Steam-jet.* **W. A. D. Rudge.** (Camb. Phil. Soc., Proc. 18. pp. 127–134, June, 1915.)—Much previous work has been done on the electrification manifested during the escape of steam under high pressure. An insulated body suitably placed in a current of steam has been found to acquire a charge which Armstrong proved to increase enormously with increase of pressure. The sign of the charge given to conductors placed in the steam current is usually positive, but occasionally negative, while its magnitude seems to be associated with the amount of disturbance present in the jet, for a quiet flow of steam is accompanied by a small charge and a noisy flow by a large charge. The author has already shown [see Abs. 1864 (1914)] that when steam under pressures escapes, it gives to the air a strong charge which persists for some time after the condensation of the steam. The experiments now to be described were made with the object of ascertaining the conditions under which a positive or a negative charge was given to the air, and also to find out whether the jet was uniformly charged. Experimental details are adequately given and diagrammatically illustrated ; the charge given up to the air was indicated by a small radium-coated collecting plate attached to an electroscope of the usual type, with single gold-leaf made double whose images were projected upon scales fixed to the wall some distance away. The results obtained are as follows :—(1) A positive charge is given to the air by the action of the jet and this persists for some time after the condensation of the steam. (2) The charge given to the air by the steam from pure water is always positive, and the presence of non-volatile substances dissolved in the water has no influence on the charge. (3) Volatile bodies mixed with the water may give a negative charge to the air. (4) The charge acquired by the air appears to be due to something which occurs in the cloud of condensed vapour. (5) Positive and negative charges can be obtained simultaneously from the same jet, by suitably placing exploring electrodes in the path of the steam. H. H. Ho.

DISCHARGE AND OSCILLATIONS.

1096. *Influence of Magnetic Field on Ionisation by Collision.* **H. Greinacher.** (Deutsch. Phys. Gesell., Verh. 17. 8. pp. 131–151, April 30, 1915.)—The paper is divided into two sections, (*a*) experimental, (*b*) theoretical. (*a*) In this section previous work by Earhart [Abs. 1099 (1914)] and others, on the effect of magnetic fields upon the phenomenon of ionisation by collision, is confirmed. After describing in detail the experimental arrangement finally adopted a series of observations and curves are given, showing how the ionisation current "I" between two parallel plates varies with the magnetic field "H" (applied transversely), only weak fields being at first considered. A second point investigated is the influence of the gas pressure, p, on the form of the (I-H) curves. Experiments are also described in which the decrease of current, observed when the magnetic field is applied, is compensated by an increase of the electric field, X, between the plates. An interesting (X-H) curve is given in illustration. A similar set of observations is now described, in this case very strong magnetic fields being used instead of the weaker fields used in the above experiments. In this connection also a comparison is made between the cases of ionisation by collision in air and in water-vapour. "Pressure-ionisation" curves, with constant electric field, with and without magnetic fields are shown. (*b*) In this section the above experimental observations are discussed mathematically. A calculation of λ, the free path of an ion, is made in particular cases. In considering the path of the "collision-ions" the effect of reflection from the gas molecules is investigated, and the loss of energy at each reflection calculated. With regard to the loss of energy the influence of the magnetic field on the free path of the ion is worked out—the previously obtained value of λ being modified on this account. The author now proceeds to consider the relation between the increase, ΔX, in the electric field necessary to compensate for the decrease of ionisation current produced by applying a magnetic field H. A theory for very strong magnetic fields is suggested to account for the observations in section (*a*). The paper concludes with a calculation of the *mean free path* of the electrons in the cases of ionisation of air and water-vapour, a table being given to show that these mean free paths are almost identical with those of the gas molecules in the respective cases. A. B. W.

1097. *Negative Thermionic Currents from Tungsten.* **K. K. Smith.** (Phil. Mag. 29. pp. 802–822, June, 1915.)—The object of this research was to make a detailed quantitative investigation of the negative thermionic emission from tungsten over a large temperature-range, and to discover, if possible, more evidence as to the conditions which determine the emission. Special precautions were taken to remove absorbed gases from the lamps used, and the final pressure, by the use of liquid air, could be made as low as 0·001 μ or less. With these arrangements it was possible to measure the emission over a range from 10^{-13} amp. up to 1 amp., and thermionic currents were obtained of the order of magnitude of the heating currents. Details are given of the results obtained with the 7 lamps employed. Considerably larger currents were obtained, at the same temperatures, than those observed by Langmuir, and this fact is attributed to the improved vacuum conditions, for, as Langmuir also concluded, the effect of residual gases is to decrease the thermionic current, especially at low temperatures. When the observations are plotted it is seen that they fall into 4 groups, and these variations in the thermionic emission seem to be the results of progressive changes in the surface conditions of the filaments. One of the most interesting results of the experiments is the enormous range of validity established for the emission formula $i = aT^{1/2}e^{-b/T}$ (where i is the saturation current in amps. per cm.^{2} and T is the absolute temperature, a and b being constants) when the conditions are such that no change in the character of the emitting surface is believed to occur. The formula is shown to hold good whilst the current is varied by a factor of 10^{12}, the corresponding range of temperature being from 1050° K. to 2800° K. An equally good agreement is shown with the formula $i = cT^2e^{-d/T}$, with c and d constants and d equal to 52,000; so that it is not possible to distinguish between the relative merits of these two formulæ with the data so far obtained. [See also Abs. 438 (1908).] A. W.

1098. *Electrons and Heat.* **O. W. Richardson.** (Nature, 95. pp. 467–470, June 24, 1915. Discourse delivered at the Roy. Inst., May 7, 1915.)

1099. *Mobilities of Ions in Air.* **E. M. Wellisch.** (Am. J. Sci. 39. pp. 583–599, May, 1915.)—A well-known result of experiment is that over a wide range of pressure, the mobility, k, of an ion in a gas varies inversely as the pressure, p, of the gas. For the positive ion pk = constant, has been verified down to 1 mm. pressure, below which Todd [Abs. 368 (1912)] found that pk markedly increased. Similarly a number of observers have found that for the negative ion pk increases at pressures below 10 cm. This indicates a simplification of the ion as the pressure is reduced. When a gas at low pressure is thoroughly dried the very large velocities of the negative ion indicate that, at least for part of its career, it is in the electronic state. The results of numerous workers are in accord so far as the general variation in pk is concerned, yet discrepancies in the actual values obtained lead one to suppose that some disturbing factor has not been detected. The experiments described here were undertaken to throw further light on the phenomenon. The mobilities of the ions were measured by the alternating electric field method. One electrode was of gauze; ions produced above it by the action of polonium are drawn to it by a steady field, diffuse through it and enter the alternating field between it and the second electrode below. The frequency of this field is kept constant and the current conveyed to the second electrode is measured by an electrometer for different values of the alternating field. By finding the critical value of the field which is just sufficient to carry the ions to the electrode the mobility of the ion can be calculated. The alternating field was produced by means of a commutator and potentiometer device first used by Langevin. The potential of the gauze is given by $+v_1$ and $-v_2$ alternately. The gas used was dry air, and for each pressure employed a curve was obtained of the current to the electrometer and the potential of the field, v_1 or $-v_2$, according as the mobility of the positive or negative ion is being examined. In the case of the positive ion the curve is produced to cut the potential axis, which determines the critical field and, hence, the mobility of the ion.

The curves obtained with the negative ion are compounded of two simple curves. One of these cuts the potential axis very close to the origin, so that the electrode begins to receive a charge for very small potentials applied to the gauze. Hence this may be regarded as due entirely to free electrons, and the curve is of the nature we should expect from a single type of carrier. The second curve is similarly due to a single type of carrier but one which has a smaller mobility. The mobility of this ion is calculated from the critical field obtained from this second curve. The lowest pressure used was 0·15 mm., but for all the pressures the mobility of the ion obeyed the relation $pk =$ constant. Thus in all cases the carrier of negative electricity is either an electron or an ion, and the ion remains unaltered in character over the whole range of pressures from 1 atmo. to 0·15 mm. There is no evidence of any intermediate stage in the nature of the negative carrier. The electrons appear in measurable quantities at pressures below 8 cm., and increase in number relatively to the ions with diminishing pressure.

The mobility of the positive ion was determined over a range from 1 atmo. to 0·05 mm. At the lower pressures a second method of determination was used in addition. Over the whole of the range the positive ion remains the same in nature, the product pk remaining unaltered. The experimental result that below 1 mm. pressure there is a simplification of the positive ion, is not confirmed.

The author gives a discussion of the results in which the view is expressed that all previous experiments on the velocity of the negative ion at low pressures are based on the untenable assumption of the presence of an "average" ion and are thereby invalidated. T. H.

1100. *Photo-electricity.* **J. A. Fleming.** (Engineering, 99. pp. 521–522, May 7, and pp. 549–550, May 14, 1915. Tyndall Lectures delivered at the Royal Inst.)—These lectures deal with the subject in an interesting way and also describe the experiments shown in illustration. In the second lecture the action of light on gases is dealt with, especially with reference to the action of solar radiation upon the earth's atmosphere and on radiotelegraphic phenomena. L. H. W.

1101. *On the Causes of Ionisation of the Atmosphere.* **J. A. Fleming.** (Electrician, 75. pp. 848–850, June 11, 1915.)—Supplementary to the information given in the author's Tyndall lectures [see preceding Abs.]. L. H. W.

1102. *Further Researches on Ionomagnetic Rotations.* **A. Righi.** (Elettrotecnica, 2. pp. 50–64, Jan. 25, 1915. Electrician, 75. p. 815, June 4, 1915. Abstract.)—The author first gives an account of his previous work in connection with magnetic rays and the rotations produced by these rays, such rotations being termed "ionomagnetic." He then describes two modified forms of apparatus for showing the rotations [see Abs. 1870 (1914)]. The results obtained in his experiments have enabled him to arrive at an explanation of the motions on the basis of electronic theory. Thus, in a uniform magnetic field ions trace a helical path, the direction of motion depending on the sign of the particles. Hence, when an ionised gas is traversed by a magnetic field, the ions, instead of moving in a straight line after each collision with the molecules or with each other, move along helical arcs. The result is that when they ultimately collide with the lightly-mounted rotatable member the negative ions produce a torque in one direction, and the positive ions in the other, and the actual rotation observed is due to the difference in the two opposite impulses. In the first apparatus described, the rotating cylinder is electrified to a potential sufficient to ionise the surrounding gas without having recourse to extraneous aid. Rotation is in this case also produced and is more rapid than with the original apparatus. The explanation is that, owing to its being charged, the cylinder was subjected to few collisions except from ions of sign opposed to that of its own charge; ions of the same sign are repelled. In the second modification the electrodes are concentric cylinders, the rotating member being mounted between them. Under these conditions, both positive and negative ions produce torques in the same direction, and the motion of the rotor is still further accelerated. In a final experiment, rotation was produced by the impact of ions inside the rotating element, which took the form of a closed box. In discussing these results, the author observes that the conductivity of metals has long been attributed to electrons in the interior. These electrons act to some extent as if they were particles of a gas enclosed within a hollow body having the same surface as the actual conductor. These electrons, therefore, will obey the same laws as the ions in the experiments above described, and if a conductor be placed in a magnetic field, the electronic bombardment will produce a torque, and the author considers that this is the torque observed when a current-carrying conductor is placed in a magnetic field. He has examined this hypothesis mathematically, and obtains values in complete accord with those deduced from electromagnetic theory. L. H. W.

1103. *Influence of the Glow-discharge on the Volta-effect.* **A. S. Lose.** (Deutsch. Phys. Gesell., Verh. 17. 1. pp. 8–18, Jan. 15, 1915.)—The author first refers to Wertheimer's experiments in this field [Abs. 789 (1914)] in which the metal discs to be examined were made the kathodes in a vacuum vessel and a glow discharge was allowed to pass for from ¼ sec. to 30 secs. When oxygen or air were in the vacuum tube the metals, negative at the outset, were rendered more positive in the Volta series, while a hydrogen atmosphere caused a return towards the original value. Wertheimer described these effects as due to polarisation, and concluded that this polarisation was distinguished from the electrolytic phenomenon by the fact that in the latter, kathode and anode polarisation can be produced by change in current direction, while here the corresponding effects are brought about by change of atmosphere and not by change of direction. This assertion is in contradiction to Gaede's results, who found a polarisation of the Volta-effect exactly analogous to the electrolytic phenomenon, *i.e.* change of sign with change of current direction. The present paper is the result of an experimental investigation undertaken to solve this contradiction. Very full details of the apparatus used are given. First Wertheimer's experiments were repeated with a large number of metals, namely: Pt, Au, Ag, Cu, Fe, Steel, Cr, Ni, Ta, Pb, Cd, Zn, and Al. These were examined after being rubbed with emery and also when not so treated, in order to study the influence of the oxidation film on the phenomenon. All the metals except Al and Zn changed towards positive as against negative at the outset. With Pt, Au, Ag, Cr, and Pb the Volta-effect slowly decreased from its original value, while the others changed more quickly and then after an interval manifested a negative polarisation, which after attaining a maximum slowly declined again. Thus the curves for these metals show a transition-point which suggests the presence of two opposite effects operating at the same time. When therefore Gaede's experiments, which were carried out at atmospheric pressure, are performed *in vacuo*, there is a negative polarisation of the metal, due to the electric current acting against a positive effect due to the formation of ozone by the discharge. Experiments were next carried out to establish this secondary effect due to chemical action in dilute oxygen. Having determined that positive polarisation takes place with the glow discharge in air, experiments were next made to establish a negative polarisation when very short discharge intervals are employed. Details are given of the method and apparatus employed to ensure that the secondary chemical effect due to ozone formation was eliminated. All metals were found to become more negative in air or oxygen, while those not emery-treated were completely protected against ozone effects by their oxidation film. The value of the polarisation is throughout higher for the non-emery-treated metals. With metals after rubbing with emery, an ozone action is still perceptible in spite of the short discharge duration, but at the same time they are first polarised kathodic and the later positive course corresponds to the change of the Volta-effect. From these experiments it follows that Wertheimer's observed negative polarisation of the kathode in air when using short discharges is not a single phenomenon deviating from the normal behaviour of metals, but actually the primary effect unmasked owing to absence of ozone activity.

In conclusion, Wertheimer's results appear to be no new primary phenomena, but must be ascribed to the secondary action of ozone formed by the glow discharge as found by Gaede. No essential difference exists between the action of the current upon the Volta-effect at atmospheric pressure and *in vacuo.* H. H. Ho.

1104. *Distribution of Electric Force in Low-pressure Discharges.* **T. Harris.** (Phil. Mag. 29. pp. 182–192, July, 1915.)—The object of the experimental work here described was to find the distribution of the electric forces in a discharge through air at low pressures in a cylindrical discharge tube. The method used is that already employed by J. J. Thomson and by Aston, in which a fine beam of kathode rays is projected through the field of force, the magnitude of which is estimated from the deflection of the beam. The effects were determined due to the following variations:—(1) The gas pressure,

(2) the distance between the electrodes for Al and Ni kathode, (3) the diam. of the discharge-tubes. The results are plotted in curves for which the ordinates denote potential gradient and the abscissæ the distance from the kathode. All the graphs shown are concave upwards, of small slope for small distances, and very steep for the greater distances. [See Abs. 1921 (1909) and 1551 (1911).] E. H. B.

1105. *Arc and Spark.* **M. La Rosa.** (Accad. Lincei, Atti, 24. pp. 234–239, Feb. 25, 1915.)—In replying to Occhialini's criticisms [see Abs. 1877 (1914)], the author repeats his conclusion, that the nature of the spectrum emitted by a vapour or a gas traversed by the discharge should depend essentially on the power expended in a unit of the excited mass, the manner in which such power is introduced having only a secondary influence. That a preparatory phase exists with every form of discharge is definitely established, but objection is raised to Occhialini's statement that with this preparatory phase there corresponds always that type of spectrum which has been distinguished as a "spark spectrum." The author maintains that, in the discharge phenomena usually studied, superposition of the forms which have been adopted as typical is often encountered. These typical forms, which are not ideal schemes but real processes, are obtained in well-defined conditions. When the latter are altered, the discharge is no longer merely arc, or flash, or spark, but participates in the characters of at least two types. This view is justified by the continuity of the spectral transformation, which is accompanied by a succession of gradual changes in the electric elements. T. H. P.

1106. *Theory of the Positive Column.* **R. Seeliger.** (Phys. Zeitschr. 15. pp. 777–782, Sept. 15, 1914.)—A theoretical discussion of the phenomena occurring in the positive column of an electric discharge in high vacua. [See Abs. 1591 (1914).] E. H. B.

1107. *Theory of the Current in Glow Discharge.* **R. Holm.** (Phys. Zeitschr. 15. pp. 782–785, Sept. 15, 1914.)—A continuation of previous papers concerned with the discussion of the *glow current.* [See Abs. 940 and 1591 (1914).] E. H. B.

1108. *"Gliding"-sparks with Röntgen Tubes.* **B. Winawer** and **F. Pfeiffer.** (Phys. Zeitschr. 15. pp. 895–897, Nov. 1, 1914.)—Illustrations given show the branching discharge effects which sometimes occur on the outer walls of Röntgen tubes. This phenomenon shows a certain similarity to the already known "gliding"-spark appearances. The method of investigation is described. A. E. G.

1109. *Electric-wave Transmission over Earth's Surface.* **A. E. H. Love.** (Roy. Soc., Phil. Trans. 215. pp. 105–131, 1915. Roy. Soc., Proc. 91. p. 219, March 1, 1915. Abstract.)—The author obtains a solution of the general electrodynamic equations for waves excited by a doublet vibrating in presence of a conducting sphere, and adapts it to give the known solution for perfect conduction and the correction for moderate resistance, *e.g.* of sea-water, both being series involving zonal harmonics. A new method of effecting the summation is given, and worked out in detail for a wave-length of 5 km. For perfect conduction, H. M. Macdonald's result is confirmed. Resistance is found slightly to increase the strength of signals at long distances, slightly counteracting, therefore, the weakening due to curvature. A comparison with the experimental evidence, and a new but admissible interpretation of the latter brings the results of diffraction theory into good agreement with those of daylight observations at great distances.

G. W. DE T.

1110. *Electromagnetic Waves in a perfectly conducting Tube.* **L. Silberstein.** (Roy. Soc., Proc. 91. pp. 170–179, Feb. 1, 1915.)—It is shown that the only possible permanent waves will have a velocity greater than that of light. A compound wave of permanent type can be obtained by the superposition of an indefinite number of simple waves of different periods and orders satisfying the mathematical conditions, and forming a discrete set. A superposition of a continuous manifold of simple waves of a fixed order, but different periods, ranging over a continuous interval, may be obtained, and the resultant train of waves will undergo continuous deformation while moving past the tube. There will be no unique velocity, but there will be a group-velocity, and, although the velocity of each component is greater than that of light, this group velocity may be less. Such a superposition can be used to represent a wave of discontinuity, or thin electromagnetic pulse, as "Röntgen wave," provided these are axially symmetrical. A thin pulse, while moving past the tube, would be broadened out. "Hard" Röntgen rays, of axially symmetrical structure, sent through a conducting tube, should therefore be "softened." G. W. DE T.

1111. *Wehnelt Interrupter as Generator of H.F. Oscillations.* **G. A. Nilsson.** (Jahrb. d. Drahtlosen Teleg. 9. pp. 127–140, Dec., 1914.)—The author has investigated a high-frequency oscillating circuit consisting of a capacity and inductance in parallel with the Wehnelt interrupter. Other investigators have used capacities in parallel with the interrupter, but these capacities have always been large, and the main object has been to elucidate the action of the interrupter itself. The author deals solely with the h.f. oscillations generated. The Pt electrode was about 2 mm. in diam., and its length could be varied by means of a screw. In the first place a pressure of 120 volts was applied to the interrupter through a choking coil, while the main current and the h.f. current were measured. It was found that there is a definite length of Pt electrode, for which the h.f. current is a maximum. At this point the direct main current is a minimum. In making the above determination the capacity and inductance were maintained constant. The latter were now varied, and the damping investigated by the usual resonance method. It is shown that the smaller the ratio of capacity to inductance, the smaller is the damping. When this ratio is fairly large the oscillations are strongly damped. The author automatically registers his resonance curves by using the same motor to rotate the condenser handle and a photographic drum, on which the galvanometer deflection is indicated. The interrupter circuit was also coupled to the measuring circuit through an intermediate circuit. Resonance curves were obtained for the latter when the electrode-length, primary capacity, and coupling were varied. I. W.

1112. *Refraction and Reflection of Electric Waves by Crystals.* **K. Uller.** (Deutsch. Phys. Gesell., Verh. 17. 2. pp. 20–34, Jan. 30, 1915.)—Purely mathematical treatment without diagrams or numerical cases. E. H. B.

1113. *Coupling of Untuned Circuits.* **M. Pavlovsky.** (Lum. Élec. 29. pp. 217–221, June 5, 1915.)—The author discusses mathematically the coupling of two untuned circuits when their resistances are neglected. The results obtained are represented graphically. I. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1114. *Selenium in Energy Measurements.* **L. P. Sieg** and **F. C. Brown.** (Iowa Acad. of Science, Proc. 21. pp. 259–268, 1914.)—The selenium cell is not available for total radiation measurements, as its range of sensibility only extends a little into the ultra-violet, and ends rather abruptly in the deep red about wave-length 0·80 μ. However, there are many experiments where it is sufficient to measure, from a source, the energy that is contained in the range of the visible spectrum. The author gives a curve of sensibility for a selenium cell, and points out that each cell must be calibrated independently. It is also shown that approximately equal amounts of light of different wave-lengths are reflected. Not more than 2 % of the incident energy was reflected, the remainder being absorbed by the cell. This indicates that the cell, when limited to the visible spectrum, is virtually a black body. The cell tested was found to be 10 or 100 times as sensitive as a linear thermopile of the type used at the Bureau of Standards. The author has tested some cells which have given equal sensitiveness throughout the visible spectrum, and hopes eventually to be able to produce such a cell at will. I. W.

1115. *Influence of Pressure on the Electrical Conductivity of Metals.* **B. Beckman.** (Phys. Zeitschr. 16. pp. 59–62, Feb. 15, 1915.)—Grüneisen has deduced from the electron theory an expression for the influence of hydrostatic pressure on the electrical conductivity of a pure metal. The author has determined experimentally the pressure effect in the case of Sn, Fe, and Pd, and has compared these results with the values deduced from Grüneisen's formula. He gives in tabular form a summary of similar measurements made by previous observers. From a consideration of all the available experimental data he concludes that the formula gives the right order of magnitude for the pressure coefficient if we exclude Bi and Hg. It represents the experimental results very closely for Au, Ag, Al, and Cu, but in general it can only be regarded as a first approximation. I. W.

1116. *High-temperature Investigation and a Study of Metallic Conduction.* **E. F. Northrup.** (Frank. Inst., J. 179. pp. 621–662, June, 1915.)—The author points out the importance of investigating physical properties over the widest possible temperature-range, and refers particularly to the results obtained in the case of metallic conduction. He gives his reasons for rejecting the free-electron theory, and proposes a theory based on the transport of electrons from molecule to molecule. I. W.

1117. *Electrical Resistance and Critical Ranges of Pure Iron.* **G. K. Burgess** and **I. N. Kellberg.** (Bureau of Standards, Bull. 11. pp. 457–470, May 10, 1915.)—The resistances of an iron wire and a Pt-wire, wound on the same support and enclosed *in vacuo* in quartz glass, were compared at very short intervals of time during heating and cooling. Six iron thermometers were used from three samples, and all gave the same characteristics for pure iron. The resistance of iron increases from 0° C. without anomalies and with a gradually increasing temperature-coefficient until the neighbourhood of A2 is reached. As A2 is approached the resistance rises rapidly, and at A2 (757° C.) there is a cusp in the temperature-coefficient curve. At Ac_3 the resistance falls abruptly, recovering in a 25 deg. interval, and above Ac_3 rises gradually again. The transformations Ac_3 and Ar_3 begin at the same temperature (894° C.), each extending over a 25 deg. interval. The reversible thermal and electrical behaviour at A2 appears to be similar to that of a pure substance at its melting-point, whilst at A3 there is a progressive change, with temperature, of the electrical and thermal properties which are not reversible, the reaction taking place at a higher temperature on heating than on cooling. The A3 change is certainly associated with recrystallisation, whilst no crystallographic change has as yet been found at A2. [See also Abs. 1888 (1914).] G. E. A.

1118. *Electric Conductivity and Density of Palladium-Hydrogen Alloys.* **G. Wolf.** (Zeitschr. Phys. Chem. 87. pp. 575-588, 1914.)—Wires of palladium from Heraeus, 20 or 27 cm. in length, 0·5 or 0·75 mm. in diameter, would not absorb hydrogen at first, particularly not after being heated by the electric current, and had to be activated by being treated alternately as anode and kathode in sulphuric acid. The amount of hydrogen absorbed is deduced from the diminution of the gas pressure in the apparatus. The change in length and thickness was measured after each absorption, and the electric conductivity was determined by a Matthiessen-Hockin bridge. The conductivity decreases as the absorption of hydrogen increases to about one-half its original value, and three steps may be distinguished in the conductivity change: (1) up to 40 vols. of H per vol. of Pd the decrease is proportional to the H-percentage; (2) from 40 to 600 vols. of H per vol. of Pd the compound PdH_2 is formed, and the conductivity decreases asymptotically; (3) above 600 vols. of H, hydrogen is dissolved in the PdH_2, and the decrease in conductivity again becomes proportional to the additional H absorbed. The three parts of the curve were also distinguished by Troost, Hautefeuille, and Krakau; the first portion concerns the period during which the hydrogen is dissolved only in palladium itself. The curve relating density with hydrogen concentration consists of a steep hyperbolic part and a straight, slightly sloping part. All the experiments were made at 18°; the pressure had in the later stages to be raised to 1·5 atmos. to accelerate the absorption. H. B.

1119. *Insulating Properties of Solid Dielectrics.* **H. L. Curtis.** (Bureau of Standards, Bull. 11. pp. 359-420, May 10, 1915.)—Methods of measuring very high resistances are discussed, diagrams being given showing how they may be applied to the measurement of volume resistivity and surface resistivity. The volume resistivities of more than 60 materials are tabulated. The effects of humidity of the air, temperature, and the magnitude and time of application of the impressed voltage, are discussed. The surface resistivity is shown to be due to a surface film, usually of water or oil, on the insulator. This is generally the important factor in determining the leakage between two conductors insulated by a solid dielectric. However, for insulators having a volume resistivity less than 10^{14} ohms-cm. and placed in an atmosphere the humidity of which is less than 25 %, the greater part of the current may flow through the body of the insulator. The surface resistivity of most materials changes through wide limits when the humidity of the surrounding air is varied. It is often a million times as great at low humidity as at high humidity. About 75 curves are given showing the change of surface resistivity with humidity for various materials. The effects of temperature and of exposure to light are also treated. I. W.

1120. *The Coefficient of End-correction.* I. **P. J. Daniell.** (Phil. Mag. 29. pp. 137-146, July, 1915.)—If an electric current passes through a long cylindrical tube of conducting material, and then out into a large hemispherical volume of the same, the total resistance is proportional to the total length of the tube plus a certain multiple of the radius, which is the coefficient of end-correction required. Rayleigh has found that this correction k is greater than 0·785 and less than 0·845, and later that $k < 0·8242$, which he opines is near the true value. The solution depends on assigning some form to the current-flow across the open end stated as a function of the distance ω from the central axis. Rayleigh assumed the axial velocity to be of the form $1 + \mu\omega^2 + \mu'\omega^4$, taking the tube radius as unity. The present author assumes a general law of the form $1 - \sum_{r=1}^{R} k_r a_r J_0(k_r \omega)$, where k_r is the rth root of $J_1(k) = 0$. R was taken as 7, and then the coefficient required was found to be $< 0·8222$. The convergence was slow, and in the work the coefficients, a_r, were found to be roughly the same as if the axial velocity were of a form $(1 - \omega^2)^{-1/3}$. In the corresponding two-dimensional case the discontinuity at the edge of the opening is just of this type. Again, Rayleigh found that the ω^4 term was of greater importance than the ω^2. All these considerations have led the author to assume a form $A + B(1 - \omega^2) + C(1 - \omega^2)^{-1/3}$ for the axial velocity, or current. This forms the substance of the paper, and it is found: (1) That B is small and its effect on k almost negligible; (2) that if the total current is π and the radius 1, the axial velocity is very nearly $\frac{1}{2} + \frac{1}{3}(1 - \omega^2)^{-1/3}$; (3) that $k < 0·82168$ and is extremely close to this value.

H. H. Ho.

1121. *Bismuth-Silver Thermopiles.* **W. W. Coblentz.** (Bureau of Standards, Bull. 11, No. 1. pp. 131–137, Nov. 15, 1914.)—The linear thermopile consisting of Bi and Ag wires with rectangular receivers attached to the junctures of these two metals has all the advantages of a good bolometer with none of its disadvantages. Its novelty consists in a series of overlapping receivers forming a continuous surface. The object of the present paper is to illustrate various modifications and uses to which this instrument has been adapted and to indicate further applications. The continuous surface of the receiver has a definite area that permits calibration for determinations in absolute measure. Data are given on the relative sensitiveness of thermopiles of Bi-Ag, Bi-Cu, Bi alloys, and of Bi-Fe. It is shown that the attainment of a high radiation sensitivity in a thermopile is mainly a question of neatness of construction (low heat-capacity, conductivity, and emissivity) and that the thermoelectric power is of secondary importance. The radiation sensitivity of a thermopile of Bi and Ag is within 10 % as high as that of a thermopile of Bi alloy having a 55 % higher thermoelectric power. These thermopiles have practically the same radiation sensitivity as a good air bolometer, and they are not so easily disturbed by air currents. They possess all the good qualities, except instantaneousness of action, of the bolometer.

Experiments are described on the radiation sensitivity of a thermopile as a function of the area exposed and of the thermo-conductivity and emissivity; also as a function of the external and the internal resistance. It is shown that the external (galvanometer) resistance may be 2 or 3 times the internal resistance without decreasing the sensitivity more than 5 or 10 %. A radiometer attachment to monochromatic illuminators is described which enables the operator quickly and easily to determine the energy value of the stimulus. This is of value for investigations on the effect of light-stimuli on matter. A thermopile with a thin blackened strip of manganin or Pt in front of it is described. This affords a quick and accurate method for the measurement of radiant energy in absolute measure.

Special forms of thermopiles designed for various purposes are described—

such as stellar thermopiles, thermopiles for measuring nocturnal radiation or the small electric currents in radiotelegraphy, etc.

The results described have involved the construction of more than 1000 thermal elements. It is noted that the thermopile and bolometer recognise no sharp dividing line of "ultra-violet," "visible," and "infra-red." Using a suitable spectrometer, it is just as easy to observe in the ultra-violet as in the extreme infra-red. The thermopile deserves a trial as compared with the spectrophotometer, which is limited in range, and as compared with photographic photometry with its sources of doubt. Various appendices are attached to the paper treating of galvanometer mirrors, vacuum galvanometers, the most efficient combination of thermopile and galvanometer resistance, test of stellar thermoelements on stars, and the maintenance of high vacua by means of metallic calcium. J. J. S.

1122. *Effect of Temperature on Pyroelectric Phenomena.* **W. Ackermann.** (Ann. d. Physik, 46. 2. pp. 197–220, Jan. 28, 1915. Abstract of Dissertation, Göttingen.)—The pyroelectric constant γ is defined as the quantity of electricity per sq. cm. normal to the pyroelectric axis for 1 deg. change of temperature of the crystal. The author has measured this constant for tourmaline (6 specimens; range —250° C. to 375° C.), lithium sulphate, lithium selenate, neutral potassium tartrate, sodium lithium selenate, potassium lithium sulphate, d-ammonium tartrate, sodium lithium sulphate, and strontium ditartrate (range —250° C. to 79° C.). The crystals were in the form of parallelopipeds 12 mm. long, the pyroelectric axis being parallel to the length of the crystal. For observations below 100° C. the ends were first silvered, then a layer of copper was deposited, and to this copper wires were soft-soldered. For observations above 100° the copper wires were silver-soldered to small copper cups which were pressed on to the ends of the crystal, a layer of silver-foil intervening. The quantity of electricity produced at one end of the crystal for a small change of temperature was compensated by the charge induced on a condenser plate by a suitably applied voltage. Balance was determined by the aid of a Hankel thread electrometer. To obtain small changes in the temperature of the crystal it was placed in an air chamber consisting of a brass tube round which was wound a heating coil. Surrounding this was another concentric brass tube. This air chamber could be placed in a suitable constant-temperature bath. By the passage of a current round the heating coil the temperature of the crystal could be raised slightly (1·5 to 2·5 deg.) above the inital bath-temperature, and the pyroelectric effect determined. The results show that the constant γ diminishes with decreasing temperature and would vanish at —273° C. The following values were obtained for a tourmaline of a greenish-yellow colour:—

Temp. C.	—250°	—185°	—75°	—20°	1°	21°	79°	99°	135°	215°	305°	375°
γ (c.g.s.)	0·08	0·292	0·987	1·213	1·251	1·294	1·349	1·360	1·390	1.501	1·683	1·87

The magnitude of the effect varies slightly with the colour of the tourmaline. The effect of change of temperature on γ for all the crystals investigated is of the same general character. L. L.

1123. *Experimental Proof of Ampère's Molecular Currents.* **A. Einstein and W. J. de Haas.** (Deutsch. Phys. Gesell., Verh. 17. 8. pp. 152–170, April 30, 1915.)—On the electron form of the theory of the molecular currents which form the permanent magnetic elements of a magnetic substance the magnitude of certain interactions between an iron cylinder and alternating magnetic fields is calculated. The arrangement has also been realised experimentally and the deflection observed optically. The observed and calculated quantities differ by less than 2 per cent. E. H. B.

1124. *Temperature Coefficient of Potential Difference of Metal-vacuum* **W. Schottky.** (Deutsch. Phys. Gesell., Verh. 17. 7. pp. 109–121, April 15, 1915.)—A theoretical investigation of which the following is the chief result:—The temperature coefficient of the work of emission or of the *potential discontinuity at the surface* is not equal to zero, but is equal to the negative change of the proper energy of the metal per emitted the electron divided by the absolute temperature. E. H. B.

1125. *Electrically-maintained Vibrations.* **S. Butterworth.** (Phys. Soc., Proc. 27. pp. 410–424, June, 1915.)—A theoretical paper of which the following are the chief results:—(1) A vibrating system of one degree of freedom when set in motion by the interaction of a current on a magnetic field is shown to behave as a parallel combination of capacity, conductance, and inductance. (2) When set in motion by the interaction of charged bodies on an electrostatic field it behaves as a series combination of inductance, resistance, and capacity. (3) The corresponding electrical equivalents for systems of many degrees of freedom are obtained. (4) Methods of balancing the systems on alternating-current bridges are discussed. (5) Experiments illustrating the theory in the case of a vibrating wire are quoted. (6) It is shown that a moving system of charged bodies can explain absorption and residual charge in condensers [see Abs. 1782 (1914)].

E. H. B.

1126. *Arrangement to show "Resonance."* **P. Ludewig.** (Phys. Zeitschr. 16. pp. 13–15, Jan. 1, 1915.)—The interaction in question occurs between two magnets. One is a magnetic compass needle, the other is a magnet, mounted on a horizontal axis in the magnetic meridian, so that on rotation its poles when in their lowest position are on a level with the compass needle and just north of it. The rotation is effected by a pulley and cord.

A second arrangement is described in which the interaction occurs between circuits each having a capacity and an inductance. E. H. B.

1127. *Thomson Bridge Measurements.* **F. Wenner** and **E. Weibel.** (Bureau of Standards, Bull. 11. No. 1. pp. 65–68, Nov. 15, 1914. Electrician, 74. pp. 17–18, Oct. 9, 1914. Abstract.)—Describes convenient methods for adjusting the Thomson bridge when very low resistances are measured. The adjustments are made without the repeated opening and closing of the low-resistance connection between the two low-resistance arms.

F. E. S.

1128. *New Braun-tube Oscillograph.* **F. C. Kock.** (Phys. Zeitschr. 15. pp. 840–848, Oct. 1, 1914.)—The essential features of several other forms of this oscillograph are described briefly. In the form devised by the author, the sensitive screen on which the rays fall is the surface of a rotating drum, mounted inside a Braun tube, so that its axis is perpendicular to the direction of the rays. The surface of the drum has the form of a double Archimedean spiral, as in the Siemens oscillograph. As the radius of this spiral increases proportionally to the angle of rotation of the drum, a ray incident on the surface experiences a deflection proportional to the time in the direction of the time axis, as the drum rotates. The axis of the drum carries an iron armature which can be made to follow the rotation of an electromagnet, the poles of which are shaped to fit the glass tube externally. The electromagnet is driven by a d.c. motor. In dealing with alternating-current curves an a.c. synchronous motor can be switched in to take the place of the d.c. motor and thus make the curves stationary. Such a sensitive screen can also be rotated *in vacuo* by mounting on its axis the rotor of an induction motor while the stator remains outside the vacuum tube. The magnetic deviation of the kathode rays is produced in the usual way, and precautions are taken to prevent the magnetic fields of the driving machinery from acting on the rays. The two limbs of the Braun tube are shaped somewhat like the two prongs of a tuning-fork so that two kathode streams can be used. The tube is excited by an influence machine. Condenser plates are provided so that the electrostatic deflection can also be used. The curves obtained can be observed in an undarkened room; in a darkened room they can be made visible to an audience. I. W.

1129. *Variable Resistance for Radio-active Measurements.* **M. Siegbahn.** (Phys. Zeitschr. 16. p. 10, Jan. 1, 1915.)—The resistance is the gas between one of two semicircular plates C and D, placed horizontally and nearly in contact along their bases, and an upper circular plate AB, one semicircular under-half of whose surface is covered with black uranium oxide. This upper plate may be rotated, its positions being indicated by a pointer and scale. Graphs are given showing that when the resistance between AB and C is a maximum, that between AB and D is a minimum. The resistance plotted against angle shows almost a linear relation. [See Abs. 1201 (1912).] E. H. B.

1130. *A Vacuum Furnace for the Measurement of Small Dissociation Pressures.* **R. B. Sosman and J. C. Hostetter.** (Washington Acad. Sci., J. 5. pp. 277–285, April 19, 1915.)—The furnace is built up in two parts—namely, the furnace tube which serves both as the heating element and to enclose the inner vacuum, and the water-cooled jacket which encloses the outer vacuum. The inner tube is made of an alloy of Pt containing 20 % rhodium which is much stiffer than pure Pt, and does not possess the volatility of a similar iridium alloy. The tube is protected by a sheath of magnesia, and is heated by alternating current introduced by means of water-cooled leads. Vacuum is maintained by means of a Gaede molecular pump. Charges are carried in small Pt crucibles suspended from Pt-wires. The outer vessel consists of an inverted iron pot closed at the bottom by means of a disc of stone through which pass the leads for the heating current and the steel extension tube of the furnace proper. The jacket is evacuated by means of a May-Nelson pump, and is cooled by a coil of lead piping carrying a current of water. A current of 580 amps. at 1·8 volts is sufficient to maintain the temperature of the inner tube constant at 1450° C., and there is quite a considerable length of the tube over which the temperature gradient is very slight. F. C. A. H. L.

ALTERNATING CURRENTS AND MAGNETISM.

1131. *Intrinsic Field of a Magnet.* **J. R. Ashworth.** (Manchester Lit. and Phil. Soc., Mem. 58. No. 11. pp. 1–6, March 15, 1915.)—A development along the line according to which magnetic properties of the ferromagnetic bodies above their critical temperatures may be represented by an equation exactly analogous to the gas equation. The view of ferromagnetism adopted requires that there should be an intrinsic field analogous to the intrinsic or molecular pressure in a liquid. If the quantity analogous to the gas constant R is to be treated as constant over the whole range of temperature, the intrinsic field must be very large. Weiss found it necessary to introduce into his kinetic theory a molecular field of the same large order. So far the magnitude of the intrinsic field cannot be explained readily according to recognised laws, and it is desirable to look for additional evidence for or against the existence of such a field. An experiment is described in which two iron wires dip into the limbs of a U-tube filled with a suitable electrolyte. If one of the limbs is placed between the poles of an electromagnet, an e.m.f. is established between the wires, the unmagnetised iron wire acting like the copper in a simple cell. This has been tried by Hurmuzescu and also by Paillot, and the latter found a maximum e.m.f. for a field of 25,000 gauss. This experiment was subjected to calculation, assuming that the electrical work was equivalent to the magnetic work. Treating the intrinsic field within the iron as the unknown quantity, its magnitude was calculated and found to be of the order required by the equation—

$$(H + f(I))(1/I - 1/I_0) = R'T,$$

where $f(I)$ represents the intrinsic field. If R' is unique and constant below and above the critical temperature, and equal to the reciprocal of Curie's constant, the intrinsic field in iron is of the order 10^7 gauss. G. E. A.

1132. *Hysteresis Losses in Rotating Fields.* **R. Gans** and **R. Loyarte.** (Archiv f. Elektrotechnik, 3. pp. 139–150, 1915.)—The authors point out the lack of agreement in the results of experiments on hysteresis losses in rotating fields made by various investigators. Weiss and Planer's results [Abs. 480 (1908)] show that the loss increases with B, reaches a maximum, then diminishes with further increase of B. Hermann [Abs. 734B (1910)] finds the loss to increase continually with increasing B, and considers there is no essential difference between rotating and alternating magnetisation.

In the present investigation a steel disc placed centrally between the poles of a du Bois electromagnet has its plane normal to the pole-faces. The induction B in the disc for a given exciting current in the electromagnet can be measured when the disc is stationary. When the disc is rotated about an axis through its centre, perpendicular to its plane, B rotates through an angle ϕ, but is assumed to remain constant in magnitude. A coil, wound on a fixed frame, encircles the disc about that diameter which is normal to the pole-faces and the flux through this on turning the disc (or reversing the direction of rotation) is proportional to $B \sin \phi$. The quantity of heat developed per revolution is $q = H_0 B \sin \phi / [2(1 - P/4\pi)]$, where H_0 is the external field and P the demagnetising factor of the disc. It is independent of the velocity of rotation of the disc. The angle ψ between B and the true field H in the disc when it is rotating is given by $\sin \psi = 2q/HB$. For any particular value of B the corresponding H is determined from a B-H curve for the material of the disc. Two discs of annealed steel were used (coercive force 13–14·5 c.g.s. units). The following results were obtained :—

Disc 2·99 cm. diam., 0·195 cm. thick.

$B \times 10^{-3}$	2·62	4·44	7·80	9·25	13·90	17·02	18·95	19·60
$q \times 10^{-3}$	11·4	26·10	49·94	66·25	86·04	71·17	51·22	38·68

ϕ at first increases rapidly with B and then diminishes more slowly. Max. $\Phi = 3^\circ\, 18'$ for $B = 1500$.

Disc 2·98 cm. diam., 0·125 cm. thick.

$B \times 10^{-3}$	3·85	6·72	10·90	14·00	16·00	17·30	18·85	20·00
$q \times 10^{-3}$	19·89	41·16	71·17	85·17	83·47	71·90	47·64	32·81

Max. $\phi = 4^\circ\, 18'$ for $B = 2500$.

The hysteresis loss thus increases with B attains a maximum at $B = 13{,}900$ and then diminishes with further increase of B. This is in accordance with the generally accepted view. The angle ψ ($= \phi$ for infinitely thin disc) has its max. value 68° corresponding to $H = 14$, $B = 6000$. L. L.

1133. *Rotation of Cylinder of Graphite in Magnetic Field.* **L. Tieri.** (N. Cimento, 9. pp. 102–108, Jan.–Feb., 1915.)—A disc of bismuth suspended in a magnetic field and heated at the centre experiences a couple, due to the current corresponding to the Nernst-Ettinghausen effect. The author replaces the disc by a cylinder and uses cylinders of bismuth, graphite, silver, and copper. In the last two the effect could not be detected, and in graphite the effect is only 1/989 of the magnitude in bismuth. The effect of the disturbance due to the thermoelectric forces produced in the case of Bi is discussed. S. G. S.

1134. *Movement of Electricity in a Metallic Plate subjected to the Action of a Magnetic Field.* **O. M. Corbino.** (Accad. Lincei, Atti, 24. pp. 213–219, Feb. 25, 1915. N. Cimento, 9. pp. 13–22, Jan.–Feb., 1915.)—When a plate carrying a current is subjected to the action of a magnetic field normal to it, either the equipotential lines or the lines of flux or both—which originally formed an orthogonal system—are so deformed as to produce an isoclinic system throughout the whole plate. The Hall-effect and the distribution of potential in various cases are considered. T. H. P.

1135. *Electrical Resistance of a Plate in a Magnetic Field.* **O. M. Corbino** and **G. C. Trabacchi.** (N. Cimento, 9. pp. 118–122, Jan.–Feb., 1915.)—It has been shown that the presence of wide copper electrodes applied to the edge of a metallic plate exhibiting the Hall-effect should give rise to a system of internal currents, the superposition of these on the original current increasing the energy consumed by the Joule-effect in the plate. The result is an increase in the global resistance of the plate, *i.e.* in the ratio of p.d. at the electrodes to the total current traversing the circuit. Using a sheet of bismuth and employing experimental conditions which give results independent of the form of the electrodes, it is found that the ratio $r : r_0$ increases from 1·09 to 1·72 with increase in the field from 8400 to 10,400 gauss, r and r_0 being the resistances when the field is and is not applied. With a current traversing a circular disc between two concentric circular electrodes, the radial lines of flow become logarithmic spirals under the action of a field. The disc may be assumed to be cut along two of these spirals without modification of the distribution of the current. If, now, the magnetic field is suppressed the lines of flow will undergo marked deformation in the sector, and if the field is inverted this deformation will be accentuated. It is found experimentally, however, that inversion of the field is not accompanied by change in the global resistance of the sector. This result, which at first appears inexplicable, is readily explained by means of the principle of reciprocity enunciated by Volterra. T. H. P.

1136. *Hall-effect in a Circular Plate.* **A. Alimenti.** (N. Cimento, 9. pp. 109–117, Jan.–Feb., 1915.)—Various properties of the Hall-effect in a circular plate are deduced mathematically and are to be tested experimentally. T. H. P.

1137. *Hall-effect in Tellurium-Bismuth Alloys.* **G. C. Trabacchi.** (N. Cimento, 9. pp. 95–98, Jan.–Feb., 1915.)—The curve representing the variation of the thermo-e.m.f.—referred to that of copper—with the composition of Te-Bi alloys has been constructed by Haken [Abs. No. 851 (1910)]. This curve falls regularly from 100 to 58 % Te, then rises rapidly to an acute maximum at a composition corresponding with the compound Te_3Bi_2, next falls rapidly and finally more slowly to the Bi point. The author finds that the curve representing the Hall-effect is closely similar in character, and consideration of these two curves and also the melting-point curve indicates the probability that an intimate relation exists between the Hall-effect, the thermoelectric force, and the structure of the conductor. T. H. P.

1138. *Possible Explanation of the Hall and Ettingshausen Phenomena.* **E. H. Hall.** (N. Cimento, 9. pp. 5–12, Jan.–Feb., 1915.)—The author has shown [Abs. 745 (1915)] that reasons exist for the belief that thermoelectric phenomena in metals are produced by free electrons between the atoms, whilst the greater part of the electric current is maintained by the direct movement of electrons from atom to atom during their collisions. It is now shown that this theory is capable of furnishing an explanation of the Hall and Ettingshausen effects. T. H. P.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1139. *A Safe Metal X-ray Tube.* **L. Zehnder.** (Elektrot. Zeits. 36. pp. 49–50, Feb. 4, 1915.)—The use of an ordinary glass X-ray tube in medical work generally involves the employment of a series of screens for the protection of the operator and those parts of the patient which are not under examination. In this paper the author describes an X-ray tube which he has designed and which is comparatively safe, the use of protecting screens being unnecessary. The peculiarity of this tube is that it is made almost entirely of metal, so that all the rays not travelling in a certain direction are absorbed by the walls of the tube. The central portion consists of a brass cylinder containing an Al window through which the X-ray beam from the antikathode passes practically unabsorbed. The electrodes are introduced into the central brass tube through porcelain sheaths which are fitted over the ends of the tube and suitably sealed. By means of a side chamber containing charcoal the hardness of the bulb can be controlled.

For further details of the construction and action of this type of bulb the original paper should be consulted. A. B. W.

1140. *Soft Soda Glass, suitable for X-ray Bulbs.* (Chem. News, 111. p. 309, June 25, 1915.)—The Glass Research Committee of the Institute of Chemistry find that a glass such as that recently recommended by them for X-ray bulbs [Abs. 771 (1915)] does not give a green phosphorescent glow if made from approximately pure materials, the slight glow then observed being blue. The green phosphorescence, which appears to be preferred by users of X-ray tubes has been traced to the presence of manganese, and the glass referred to above will give this glow if manganese dioxide is added to the batch mixture in the proportions frequently used to correct the colour due to iron. T. H. P.

1141. *Green Fluorescence of X-ray Tubes.* **H. Jackson.** (Nature, 95. pp. 479–480, July 1, 1915.)—The sole advantage of the green fluorescence of X-ray tubes [see preceding Abs.] appears to be that it provides the operator with a convenient rough indication of the "hardness" of the tube. The quality of the X-rays is in no way influenced by the nature of the fluorescence of the glass, and, further, experiment shows that a strong green fluorescence is obtainable only at some sacrifice of the excellence of the glass. The addition of manganese would necessitate the adding of iron also in order to correct the amethyst colour produced by the Mn, and such procedure seems to impair the working qualities of the glass, which is better if Fe and Mn are avoided. The evidence available indicates that something akin to crystalline structure is obtained in a glass more readily in presence than in absence of Mn, and, although this tendency to crystallisation does not interfere with the use of the glass under ordinary working conditions, no advantage accrues from fostering it. T. H. P.

1142. *Ionising Potential of a Röntgen Tube.* **E. C. Drew.** (Frank. Inst., J. 179. pp. 697–709, June, 1915.)—This research was undertaken to investigate the truth of the assertion, that it takes a much higher voltage to break down the gap between the electrodes of a Röntgen tube and start the ionising currents flowing than it does to maintain this flow, once started. Although the work has not been carried to completion, it was thought desirable to publish the preliminary work, to which additions will be made in the near future. In making a choice of methods, the sine-wave form of the present type of high-tension machines generally used for tube excitation, and the loop oscillograph seem to lend themselves well to the work in view. A schematic diagram is given which shows the arrangements of the principal features of the apparatus. The tubes used were of the standard commercial type.

The hydrogen tube has been used to a far greater extent because of its great flexibility, which enables the operator to control the vacuum in either direction, up or down. From the curves obtained it is seen that the oscillograms point to the X-ray tube as a constant potential device which tends to maintain a constant drop across it. The approach of the potential-current curves to a half loop of the ordinary magnetic hysteresis cycle is notable, and is indicative of something different from a straight-line law, like Ohm's law, in the tube circuit; in fact, it would seem that the law connecting the current and potential in a circuit of this kind is that of the ordinary saturation curve. The area enclosed in this loop is a measure of the energy of ionisation. The energy which goes into ionisation in the hydrogen tube is apparently a greater percentage of the total energy supplied than in the M. and W. tube. This may account for the fact that more heat appears during operation in the latter case than in the former. There appears to be an ionisation potential distinct from the running potential. However, it is nothing of the order that is generally supposed.

It is best not to carry interpretations too far at the present stage of the work. Certain errors known to exist are stated. A. E. G.

1143. *Localisation and Extraction of Magnetic Projectiles by means of Electro-vibrator.* **J. Bergonié.** (Comptes Rendus, 160. pp. 666–668, May 17, 1915.)—A varied experience in the use of electro-magnetism on the wounded has been gained since the author described his method of extracting magnetic fragments of shell, etc. [see Abs. 767 (1915)]. Some further instructions on what has been found to be the best method of procedure are now given.

A. E. G.

1144. *Radioscopic Localisation of Projectiles in the Human Body.* **J. Villey.** (Comptes Rendus, 160. pp. 687–689, May 25, 1915.)—The arrangement described does not give any greater amount of precision than the Hirtz compass [Abs. 768 (1915)]. The position of the projectile is obtained in about 20 minutes by a series of mechanical operations which are described in detail. Calculations and radiographic manipulations are thus dispensed with, and there is the additional advantage that the necessary apparatus is quite easily constructed.

A. E. G.

1145. *Depth of Projectiles.* **Morin.** (Archives d'Él. Médicale, 23. pp. 187–189, May, 1915.)—An instrument is described which is intended to overcome some of the difficulties attending the usual method by triangulation of obtaining the depth in the tissues of a foreign body. In principle this instrument is very similar to the ordinary photographic stereoscope, and perfectly sharp stereoscopic radiographs are obtained with it.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1146. *A Collodion Diffusion Cell for use in Dialysis.* **T. R. Briggs.** (J. Phys. Chem. 19. pp. 377–380, May, 1915.)—The author suggests the use of Soxhlet extraction thimbles impregnated with collodion as convenient cells for dialysis, and the method of preparing these is described. Since in the preparation of collodion diffusion membranes the latter become impermeable to water if the collodion is allowed to dry completely during preparation, the author adds a small amount of glycerol to the collodion solution. Such cells may be completely dried without losing their permeability to water, and may be kept for a long time before using. Although the new form of collodion diffusion cell is more efficient than the ordinary type of parchment thimble, it is less efficient than collodion sacs prepared by Novy's method. A. F.

1147. *Diffusion and Absorption of Hydrogen in Quartz Glass.* **H. Wüstner.** (Ann. d. Physik, 46. 8. pp. 1095–1129, April 30, 1915. Extract of Dissertation, Leipzig.)—The diffusion of hydrogen through non-crystalline quartz glass is found to consist of a process of diffusion through an absorbent solid, this being expressed by the equation—

$$M = -q\int_0^t k\left(\frac{\partial\rho}{\partial x}\right)_{x=0} dt,$$

where M is the quantity of gas taken up at the plane of separation in time t, ρ the concentration, x the distance of a point in the diffusion space from the plane of separation, q the diffusion area, k the coefficient of diffusion, and ∂ the density. A fresh quartz vessel must be used for each measurement, since low results are obtained otherwise, the wall of the vessel being partly saturated with hydrogen from the preceding experiment; this difficulty may also be overcome by using very thin walls, which give greater effects, while, in addition, the absorption becomes unimportant in comparison with the diffusion. Experiments were made at a number of temperatures ranging from 300° to 1000°, and at pressures between 800 and 900 atmos. For the diffusion of hydrogen in quartz the coefficient k varies exponentially with the temperature. Two experiments at 600° and at 400 and 1000 atmos. gave almost identical values for M, Henry's law being consequently obeyed. This result is confirmed by measurements made, in an apparatus of another type, at 1000° and 3 atmos. The coefficient of absorption of hydrogen by quartz increases more rapidly than the temperature from 300° to 900°, the value at the latter temperature being slightly higher than at 1000°. At 700° to 1000° the absorption of hydrogen by quartz is of the same order of magnitude as the absorption by water at the ordinary temperature.

Nitrogen at 900° and 1000 atmos. diffuses far more slowly than hydrogen. At 900° and 900 atmos. oxygen attacks the mercury seal of the apparatus, measurement of its diffusion being rendered impossible. T. H. P.

1148. *Structure and Properties of Glass.* **G. Quincke.** (Ann. d. Physik, 46. 8. pp. 1025–1053, April 30, 1915.)—The cooling of molten glass is accompanied by the periodic separation at short intervals from a liquid A of thin, invisible layers of oily liquids, B, B_1, B_2, rich in silicic acid. Each of these liquids, A to B_2, is very pasty, and contains several allotropic modifications of silicic acid, the constituents being mainly the same, but their proportions different, in the different liquids; their pastiness increases as the temperature falls. The quantities of the allotropic forms of silicic acid and the physical properties of the liquids vary with the history of the glass, with the initial and final temperatures, and with the length and rapidity of cooling and heating. Owing to surface tension at the boundary between A and B, the layers of the latter roll up into open or closed structures, which may be cylindrical, conical, or spiral, or may consist of parallel, radiating, or branched tubes, hollow fibres, or resemble sphero-crystals, fir-trees, or rose-leaves. These foam-walls of type I change during the course of years into a second type, consisting of spherical and plane walls, like soap-lather; the slowness of this change increases with the viscosity of liquids A and B. The thinner the foam-walls and the smaller the foam-chambers they surround, the longer will the liquids A and B remain liquid in the supercooled condition at the ordinary temperature.

Glass is a liquid jelly with invisible foam-walls of B, those surrounding invisible foam-chambers being filled with A. The liquid jelly is transformed into a solid jelly when A and B solidify. At the ordinary temperature two pieces of new glass flow together in the same way as two flakes of lather or two pieces of glue, albumin, ice, or glowing iron. The surface tension at the boundary of A and B is independent of the thickness of B, so long as the latter exceeds 0·12 μ, but diminishes for smaller thicknesses. When glass is rolled, blown, or drawn out into rods and tubes, the boundary surface between A and B is enlarged and the firmness increased, so long as the foam-walls are more than 0·12 μ in thickness. When glass is warmed in an annealing oven, the foam-walls of type I rapidly change their form or are dispersed, the appearance of new forms and, later, solidification accompanying cooling. The foam-walls in new glass are probably less than 0·12 μ in thickness, old glass, which has thicker foam-walls, being not so readily cut.

Just as with a liquid jelly, glass exhibits transitory positive or negative double refraction when expanded or compressed for a short time. Both double refraction and dilatation disappear after a certain time, which is termed the time of relaxation, and may amount to a fraction of a second or to days or years; it is short for small expansions and very long for large, persistent displacements of the smallest particles of the glass.

The author's work leads to a number of other conclusions as to the changes proceeding in glass. A number of photographs are given which illustrate the various structures. T. H. P.

1149. *The Density of Oxygen.* **A. F. O. Germann.** (J. Phys. Chem. 19. pp. 437–477, June, 1915.)—This paper contains, first of all, an historical survey of the determinations of the density of oxygen, and a description of the special apparatus employed. As a result of his determinations with oxygen prepared by heating potassium permanganate and purified by liquefaction and fractional distillation, the author obtains the value for the weight of a normal litre of oxygen (at 0° and under a pressure of 760 mm. of mercury in latitude 45° at sea-level), of 1·42906 gm. Taking into account the previous determinations of Morley and of Rayleigh, but giving rather more weight to his own determination, the author believes that the most probable value for the weight of a normal litre of oxygen, $L_N = 1{\cdot}42905$. A. F.

1150. *Preparation of the Elements Thorium, Uranium, Zirconium, Titanium.* **D. Lely, Jr.**, and **L. Hamburger.** (Zeitschr. Anorg. Chem. 87. pp. 209–229, 1914.)—The work was carried out in the laboratory of the Philips glow-lamp works at Eindhoven, Netherlands. The reduction of the metals from the chlorides is effected by means of metallic sodium in a vacuum (steel vessel); the reduced metals, small globules or scales, are compressed into rods which are heated as resistance by alternating currents in another vacuum furnace. The difficulties are that the raw materials (oxides) are not pure, that the chlorides, purified by sublimation, are hygroscopic, and that the preparation of rods of sufficient stability is often very troublesome; moreover, air and other metals have carefully to be excluded. The resulting compact metals generally are more stable than might be expected, and their melting-points are much below that of tungsten. In the case of thorium the electric heating of the metal of 99·9 % was effected at a pressure of 0·002 mm. of mercury; the thorium was steel-grey, very ductile, density 11·2, stable (unless finely divided) in water and diluted alkali, also in concentrated nitric acid; heated on a tungsten base it evaporated. The finely-divided uranium was too brittle to allow of compression, and was therefore heated in an alundum tube wound with molybdenum wire; it became harder and conducting at 1400°; the colour was darker than that of thorium, the uranium turning brown in air; fairly stable in water and alkalies, it dissolved in hydrochloric and nitric acids. The scales of zirconium could easily be shaped into rods; the compact metal was very ductile, resisted acids fairly well, except cold hydrofluoric acid, aqua regia, and hydrochloric and sulphuric acids (hot concentrated). Titanium was prepared by the action of chlorine on ferro-titanium with 62 % Ti at 500° maximum, so that ferric chloride alone volatilised; the metal could not be heated in rods unless they were coated with paraffin, and the purified Ti proved less ductile and more easily attacked than the other metals. H. B.

1151. *Preparation of Refractory Objects of Zirconium Dioxide.* **O. Ruff, H. Seiferheld, and O. Bruschke.** (Zeitschr. Anorg. Chem. 86. pp. 389–400, 1914.)—Zirconia itself is not plastic, magnesia too volatile, and beryllium (glucinum) oxide too expensive for crucibles. Mixed with 1 % of starch (dried paste) to facilitate the shaping under pressure, and 3 % of MgO and dried at 140°, the zirconia gives fairly strong crucibles. The crucibles shrink, when baked in a gas furnace, chiefly between 1300° and 1500°. Addition of borax is in some respects advisable; the shrinkage then takes place at higher temperature, but there is superficial carbide formation and reduction during the baking in the gas furnace. The mixture, ZrO_2 + 3 % borax + 3 % MgO answers. Clay and colloidal oxides are unsuitable as binders. The pure zirconia (from Wesenfeld, Dicke and Co., Barmen) contained 98·7 % ZrO_2, 1 SiO_2, 0·27 Fe_2O_3. Crude zirconia (85·5 ZrO_2) yields crucibles by itself, but they do not stand the high temperatures of the former, above 2200° C. All attempts at producing a glaze have failed. **O. Ruff and G. Lauschke.** (Ibid. 87. pp. 198–208, 1914.)—Further particulars. The zirconia was used in three states: as precipitated hydrated oxide, baked at 1000° or at 1400°, or as crude zirconia. The first shrinks most, the second answered best. The crucibles are to be used in electric vacuum furnaces. A certain porosity cannot yet be avoided. H. B.

1152. *Action of Silent Discharge on Mixtures of Hydrogen and Nitrogen.* **M. Le Blanc.** (Sächs. Gesell. Wiss., Ber., Math.-Phys. Kl. 66. pp. 33–63,

1914. Chem. Zentralblatt, 85. p. 117, 1914.)—Le Blanc and Davies having observed in 1908 and 1909 that the law of mass action does not seem to hold for the formation of ammonia when the silent discharge is passed through mixtures of H and N, the author suspected that the discharge changed the composition of the mixture and hence the electrical conditions. He therefore dilutes the mixtures with a large excess of inert gases, helium and neon, to keep the conditions fairly constant. Repeating the former experiments with improved apparatus, however, he finds that the phenomena are very complex, and that the yield of ammonia depends upon the dimensions of the apparatus, the density and frequency of the current, and also upon the thickness of the bulb walls. The mass law is, therefore, not applicable.
H. B.

1153. *Preparation of Colloidal Solutions by Electric Disintegration.* **D. Zavrieff.** (Zeitschr. Phys. Chem. 87. pp. 507–510, 1914.)—Svedberg modified Bredig's method by using an oscillatory discharge instead of the arc, but seems to have worked only with organic solvents. The author modifies the method further for experimenting with aqueous solutions and any metals. The electrodes of the metal in question are placed 0·1 mm. apart in water; the primary of the induction apparatus is fed with currents of 15 or 20 amps. at 120 volts through a Wehnelt interrupter; the secondary comprises an oil condenser of a capacity of 4025 cm., additional self-inductance is not needed; the spark-gap can be increased to 20 cm. Colloidal solutions of Fe, Cu, and Al could be kept for a month, Mg for a few days; in the case of Co, Ni, and Zn the coil was better replaced by a Holtz machine. In order to atomise mercury, two glass tubes (1 mm. internal diam.) are bent like horns and made to enter a glass beaker in which the mouths of the tubes approach one another within 2 mm.; the tubes contain mercury and, in their outer ends the wires from the coil; the beaker is filled with water. H. B.

1154. *Absorption of Nitrogen by Calcium.* **R. Brandt.** (Zeitschr. Angew. Chem. 27. p. 424, July 7, 1914.)—Preliminary communication. Contrary to other statements, the author finds that compact calcium (pieces of from 3 to 5 gm.) absorbs nitrogen readily and almost quantitatively above 300°. The maximum of the reaction takes place about 440°; it falls off above 650°, but the fused Ca again takes up nitrogen. The solid Ca retains its shape completely when absorbing the gas, without developing cracks; the nitride Ca_3N_2 is hard, can be cleft with the aid of a chisel and be reduced to a brown powder in an agate mortar. H. B.

1155. *History of the Metallurgy of Iron and Steel.* **R. A. Hadfield.** (Inst. Mech. Eng., J. No. 5. pp. 317–357, May, 1915.)—With regard to the modern aspect of the subject the author deals mainly with his own researches.

1156. *Interchange of Atoms between Solid and Liquid Phases.* **G. v. Hevesy.** (Akad. Wiss. Wien, Ber., Jan. 14, 1915. Phys. Zeitschr. 16. pp. 52–55, Feb. 15, 1915.)—According to the kinetic theory of molecules, if a liquid is in contact with its saturated vapour a definite interchange of molecules of both phases takes place. Consequently it is to be expected that a similar interchange takes place between the two phases when a solid body is in contact with its saturated solution. This phenomenon is now investigated by radiochemical methods. In particular, an examination is made of the interchange of atoms between the two phases—metallic lead and lead nitrate solution.

Thorium B (isotopic with lead) is mixed with the lead in one of its phases and observations are made on the amount of this ThB, passing in a given time into the other phase: the ThB acts as an "indicator" of the amount of lead changing phase. Observations of this character, in the cases of $Pb/Pb(NO_3)_2$ and $PbO_2/Pb(NO_3)_2$ are tabulated and their theoretical bearing is discussed.

The author points out that a much closer approach to the ideal case of "kinetic interchange"—*i.e.* interchange with complete thermodynamical equilibrium between the two phases—is obtained by the use of the stable PbO_2 than by employing metallic lead, the use of the latter being open to serious criticism. A. B. W.

1157. *Molecular Condition and Electric Conductivity of Crystalline Salts.* **C. Tubandt** and **E. Lorenz.** (Zeitschr. Phys. Chem. 87. pp. 513–542, 1914.)—Little is known about the molecular condition in solid crystals, but Tammann's theory of polymorphism gives a partial solution of the problem. This theory attempts to reduce the determination of the molecular weight in the crystal to that of the liquid from which the crystal grew. The determination of the electric conductivity brings the melting and transition points out very clearly. The experiments were made with the chloride, bromide, and iodide of silver and thallium, these compounds being fused in a U-tube of porcelain, into the widened limbs of which cylindrical electrodes of Pt were inserted; the tubes were placed in an electric oven, in which the bottom and top temperature did not differ by more than 3 deg. Measurements were made over a wide range of temperature, from 650 to 125°, *e.g.* in the case of AgCl. This silver chloride melts at 552°; the solid AgCl conducts better than the liquid; there is hence a break in the curve at 552°, and another break is found at 144·6° (where the conductivity falls from 1·31 to 0·00034), the transition-point of the crystals from the regular to the hexagonal system. Silver bromide and iodide show breaks only at their melting-points, 442° and 455°. In the thallium iodide, bromide and chloride the breaks occur only at the melting-points, 436°, 457°, 426°. It is therefore concluded that the supposed liquid-crystalline forms of the silver and thallium halides are really plastic mixtures due to impurities. That the conductivity is entirely electrolytic in these cases is shown by the fact that the anode loss (Ag anode, Pt kathode) agrees within 0·75 % with Faraday's law, when a current is passed through the liquid or solid AgI. In mixtures of the fused salts Faraday's law does not hold quite so well. Solid AgI is more strongly dissociated than the molten salt, and the migration velocity of the Ag-ion at the temperature of the melting-point is $1{\cdot}13 \times 10^{-8}$ cm./sec., and thus twice as large as that of the Ag-ion in aqueous solutions. This high velocity is explained on the theory of R. Lorenz (Nernst Festschrift, p. 276, 1912), according to which the apparent migration velocity is made up of the actual velocity of the ion (between the molecules of the medium) and the velocity with which the ion reacts with the molecule of the medium. As the internal friction increases very much when the liquid solidifies, it is concluded that a very large sudden increase in the dissociation takes place in these halides on solidification, to account for the higher conductivity of the solid. H. B.

1158. *Separation of Mesothorium and Radium in the Manufacture of Thorium.* (German Pat. 269,541. Chem. Soc. J., Abs. II., p. 413, 1914.)—K. Schwab modifies the method of separating mesothorium and radium in the treatment of thorium minerals. It is customary to mix the minerals (to be treated with sulphuric acid) with enough barium salt so that, on diluting with 2 or 3 times the bulk of water, a fairly concentrated solution of sulphates is obtained. It is found, however, that the $BaSO_4$ does not then carry the mesothorium down with it. Schwab begins as mentioned; but he stirs the sulphate mud and siphons all the turbid liquid (above the unattacked quartz, titanium, iron, etc.) into from 30 to 60 times the bulk of water, which contains barium salt. This liquid is then allowed to settle in vats, in which the crude thorium phosphate falls out, together with the radium-mesothorium sulphate and also with part of the cerium phosphate, whilst most of the cerium and didymium remain in the weakly acid solution. H. B.

1159. *Passivity of Metals.* **W. Rathert.** (Zeitschr. Phys. Chem. 86. pp. 567–628, 1914.)—There are two chief theories of passivity. According to F. Flade [see Abs. 1296 (1912)] pure iron is naturally active, but becomes passive in the presence of oxygen. This view, the author states, has now been abandoned by almost everybody in favour of the hydrogen theory, according to which the metal is normally passive, but becomes active by the catalytic action of the hydrogen dissolved in the metal. The author repeats Flade's experiments with Fe, Ni, and Cr in solutions of sulphates and sulphuric acid during anodic polarisation, but arrives at different conclusions. Flade suggested a boundary potential, above which a metal was to be passive (and active below); but the changes from activity to passivity, and *vice versâ*, do not occur at the same potentials, and a metal may be in either condition, above and below this point, according to its previous treatment. Thus the potential at which iron becomes passive is dependent upon the concentration of the electrolyte during polarisation; but this does not hold for the change into activity. Both potentials depend, however, on the current density, and, therefore, on the oxygen concentration, which behaviour supports the hydrogen (and not the oxygen) theory. Chromium follows iron more or less; it is not active in molecular hydrogen, but changes into the active form when electrolytically charged with hydrogen. Nickel differs in so far as the changes take place gradually, not at definite potentials. Passive iron does not dissolve electrolytically, but does so in accordance with Faraday's law, like chromium, when it has absorbed hydrogen by diffusion. H. B.

1160. *Evolution of Hydrogen at the Anode from Methyl Alcohol and Formaldehyde.* **E. Müller** and **F. Hochstetter.** (Zeitschr. Elektrochem. 20. pp. 367–369, 1914.)—The electrolytic oxidation of ammonia in alkaline solution (1905) having revealed peculiar differences between anodes of Pt and of Cu, the authors investigated the oxidation of alcohols with anodes of these metals and observed that hydrogen may be evolved at the anode. Methylalcohol in caustic soda yielded, in cells with Pt-anodes and a clay diaphragm, formaldehyde and formic acid, but more than 80 % of the current was consumed in liberating a gas which was essentially hydrogen (97·4 %, the rest O and CO in one case); the gas evolution became more pronounced as the electrolysis proceeded, and the anode potential rose simultaneously. The authors suspected a Kolbe reaction; but the direct electrolysis of formaldehyde or of formic acid (in alkali) did not yield gas. With a copper anode, on the other hand, the electrolysis only of formaldehyde liberated hydrogen at the anode (as much as at the kathode), whilst methyl alcohol and formic acid did not evolve hydrogen on electrolysis. E. Müller had shown in 1907 that a copper anode is first active in caustic alkali (and dissolves in it), but covers itself with oxide and turns passive; this film of oxides is velvety and is reduced to spongy copper in formaldehyde. In accordance with Euler, who regards formaldehyde as a weak dibasic acid, the authors consider that the formaldehyde can in alkaline solution discharge ions of H_2CO_3'' which split into H_2 and CO_2. H. B.

1161. *Electrolytic Deposition of Alloys. Metallographical and Mechanical Investigation.* III. *Attempts to prepare Zirconium, Antimony, and Chromium Alloys.* **R. Kremann, J. Lorber, R. Maas.** (Monatshefte d. Chem. 35. pp. 601–602, 1914.)—In continuation of former experiments, Part I. on Fe-Ni alloys, and Part II. on Cu-Sn bronzes (Ibid. 34. pp. 1757–1809, and 35. pp. 219–283), the authors find that Zr cannot metallically be deposited from an alkaline solution of its hydroxide in presence of tartaric acid with either Pt electrodes or with a mercury kathode, nor can an iron alloy be obtained from the just-mentioned solution in presence of iron salt; in this last case iron alone falls in the passive condition. Becquerel had claimed to prepare an alloy Zr-Fe in this way. Zirconium, now found plentifully in San Paolo, Brazil, would also form a promising substitute for tin in bronzes and enamels; but attempts to deposit it along with tin, or with zinc or copper from alkaline solutions likewise failed. Aluminium was added to some aqueous solutions; for, although the authors know that Al cannot electrolytically be deposited from them, not even together with other metals, Al yet seems to have some influence on the deposition of other metals; the copper from such mixed solutions of tartaric acids and potassium cyanide contained several per cent. of cuprous oxide. Antimony and copper can be deposited together from the sulphate of Cu and Al, tartar emetic and alkaline tartrate; the alloys contain rather crystals of the separate metals than of alloys. From mixed solutions of Cu and Cr a copper is deposited containing 2 % of chromium hydroxide apparently, not metallic chromium. IV. *Iron-Magnesium Alloys from Aqueous Solutions.* **R. Kremann** and **J. Lorber.** (Ibid. 35. pp. 603–634, 1914.)—According to the authors, iron can only be deposited at a low current-density unless the concentration of the $Fe^{\cdot\cdot}$ ions is diminished by the addition of magnesium sulphate or chloride. From such mixtures Fe was supposed not to take up more than 0·3 % Mg; the authors find up to 8·3 % Mg in their iron, but always also the hydroxides of the two metals. The product, further, oxidised rapidly when the air had access, beginning to glow even when preheated to 200 or 300°. The alloy seems to be a silver-white substance, probably embodying oxides; this substance and the alloy evolve hydrogen from water at 94°. Hardness tests (Martens apparatus) support the conclusions of the metallographic examination. The iron in the product is passive, as is shown by potential measurements against ferrous sulphate and against electrolytic iron. These experiments were conducted in two series, with or without addition of potassium chloride. V. *Nickel-Iron Deposits from Hot Sulphates.* **R. Kremann** and **R. Maas.** (Ibid. pp. 731–758, 1914.)—Experiments (Part I.) had been made with cold solutions, when the alloys were brittle, apparently owing to the presence of hydrogen. The sulphate solutions were hence heated up to 75°, either alone or under addition of potassium oxalate or of citric acid. The Ni percentage in the alloy increases very much (up to 70 or 80 %) by heating the bath; it also increases with the concentration of the Ni in the mixture, rapidly at first, and with the addition of the two chemicals mentioned to the sulphate bath. Carbon kathodes are preferable to iron kathodes, the deposits being then less spongy. Concentric ring systems are frequently seen on the polished surfaces of the alloys; these rings are ascribed to the presence of hydrogen bubbles about which the metals are deposited in concentric shells. The alloys from the hot solutions are harder than those from the cold solutions, and as the former metals (from hot bath) are also more noble than the latter, it is concluded that the previously observed brittleness and hardness are not due to hydrogen, but to the fact that the alloys are deposited in the passive condition, probably on account of the alkalinity close to the kathode. Being passive the alloys do not rust at first, but they change slowly. H. B.

1162. *Action of Certain Colloids on Ions during Electrolysis.* **A. Mutscheller.** (Met. and Chem. Eng. 13. pp. 353–357, June, 1915.)—An investigation of the influence of varying concentrations of gelatine on the transport number of the anions in solutions of silver nitrate and copper sulphate, shows that as the concentration of the gelatine increases the velocity of migration of the anions decreases, and gelatine, together with the adsorbed anions, migrates to the anode. A point is then reached where the gelatine-anion complex ceases to migrate, the relative migration velocity of the kathions being equal to 1. With further increase in the concentration of the gelatine the complex gathers on the kathode, where it deposits with the metal. The data show that 1/2 SO_4'' requires an addition of gelatine which is about 45 times that required to cause the same effect on the NO_3'-ion; that is, the valency of the ion has about the same effect as that noticed in ordinary adsorption phenomena. The phenomenon in question is therefore regarded as one of adsorption, and the author puts forward a scheme to explain the observed results, in which the gelatine is regarded as possessing a positive charge, by means of which it forms complexes with the anions. According to the proportion of gelatine to the anion, the complex migrates to the anode, is stationary, or migrates to the kathode. When the complex is neutral, the kathions migrate to the kathode as fast as they deposit and the deposit is then the smoothest and purest obtained. T. S. P.

1163. *Anodic Behaviour of Alkaline Borate and Perborate Solutions.* **W. G. Polack.** (Faraday Soc., Trans. 10. pp. 177–196, May, 1915.)—After a review of previous work on the electrolytic production of perborates, the author describes experiments on the electrolysis of solutions of alkaline borates of various composition and under various conditions of temperature and current density. The solutions were used as anolyte in suitable electrolytic cells, a hollow cooled anode being employed in some cases. With dilute and slightly alkaline solutions, such as would be suitable industrially for bleaching purposes, no perborate, or at most a minute trace, was formed in any of the experiments, even with the cooled anode apparatus. Even with much more concentrated solutions only a very small quantity was formed. Further investigation showed that an equilibrium was set up between the rate of formation of the perborate and its decomposition, owing to the hydrogen peroxide formed by its hydrolysis acting as a depolariser, tending to lower the anode potential and being itself destroyed. Measurements of the actual potentials obtained at the anode in certain cases, and of the effect of hydrogen peroxide on the potential, gave results which accorded well with Grube's theory of overvoltage at a Pt anode and the known electrochemical behaviour of hydrogen peroxide.

A French patent (the Pouzenc patent) for the electrochemical manufacture of perborates is discussed, and experiments were carried out on a small scale with an apparatus similar to that described in the patent specifications. It was found to give negative results in practice, no trace of perborate being formed in any of the experiments. T. S. P.